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INDEX TO EXECUTIVE DOCUMENTS OF HOUSE OF REPRESENTATIVES.

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CONTENTS OF THE VOLUMES.

Vol. 1.—MESSAGE OF THE PRESIDENT AND FOREIGN RELATIONS, 1893: No. 1, pt. 1.
Vol. 2.—REPORT OF THE SECRETARY OF WAR, 1893: No. 1, pt. 2, vol. 1.
Vol. 3.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 1.
Vol. 4.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 2.
Vol. 5.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 3.
Vol. 6.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 4.
Vol. 7.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 5.
Vol. 8.— Report of the Chief of Engineers: No. 1, pt. 2, vol. 2, pt. 6.
Vol. 9.— Report of the Chief of Ordnance: No. 1, pt. 2, vol. 3.
Vol. 10.— Report of the Inspector-General: No. 1, pt. 2, vol. 4.
Vol. 11.—REPORT OF THE SECRETARY OF THE NAVY, 1893: No. 1, pt. 3.
Vol. 12.—REPORT OF THE POSTMASTER-GENERAL, 1893: No. 1, pt. 4.
Vol. 13.—REPORT OF THE SECRETARY OF THE INTERIOR, 1893: No. 1, pt. 5, vol. 1.
Vol. 14.— " " " " " " No. 1, pt. 5, vol. 2.
Vol. 15.— " " " " " " No. 1, pt. 5, vol. 3.
Vol. 16.— Report of the Director of Geological Survey: No. 1, pt. 5, vol. 4, pt. 1.
Vol. 17.— " " " " " " No. 1, pt. 5, vol. 4, pt. 2.
Vol. 18.— Report of the Commissioner of Education: No. 1, pt. 5, vol. 5.
Vol. 19.—REPORT OF THE SECRETARY OF AGRICULTURE, 1893: No. 1, pt. 6.
Vol. 20.—REPORT OF COMMISSIONERS OF DISTRICT OF COLUMBIA, 1893: No. 1, pt. 7.
Vol. 21.—No. 1, pt. 8, and Nos. 4, 7, and 23.
Vol. 22.—No. 2: Finance Report, 1893.
Vol. 23.—No. 3, pts. 1 and 2: Report of the Comptroller of the Currency, 1893.
Vol. 24.—Nos. 5, 33, and 103.
Vol. 25.—No. 6, pts. 1 and 2, and House Mis. Doc. No. 96.
Vol. 26.—Nos. 8 to 96, inclusive, except Nos. 23, 33, 47, 48, 70, 76, 79, 83, and 95.
Vol. 27.—Nos. 47, 48, 70, 76, 79, 95, 112, 140, and 256.
Vol. 28.—Nos. 83, 97, and 237.
Vol. 29.—Nos. 98 to 261, inclusive, except Nos. 103, 112, 140, 209, 237, 256, and 257.
Vol. 30.—No. 209: Ninth Annual Report Commissioner of Labor, 1893.
Vol. 31.—No. 257: Report Commissioner of Labor—Slums of Cities.

Subject.	No.	Vol.
A.		
Adjutant-General, letter of Secretary of Treasury transmitting estimate for contingent expenses in office of	155	29
African slave trade, letter of Secretary of Treasury transmitting estimate to cover part of expenses of the special bureau relating to	72	26
Alaska:		
Letter of Secretary of Treasury transmitting estimate for improvement at Seal Island	207	29
Salmon fisheries, letter of Secretary of Treasury for appropriation for protection of	215	29
Appropriations:		
Book of Estimates of	5	24
Custom duties (for collecting)	52	26
Deficiencies in, estimate	33	24
Deficiency for Interior Department	37	26
Deficiencies, estimate for the several Departments	103	24
Department of Justice (deficiency)	126	29
Fish Commission, estimate for support, etc	35	26
Foreign missions (incidental expenses)	118	29
Fortifications, letter of Secretary of War transmitting amendment to bill making appropriations for	82	26
Indian appropriation bill—		
Letter of Secretary of Treasury submitting amendment to section 2 of	255	29
Letter of Secretary of Treasury transmitting recommendation for amendment to bill	87	26
Marine Corps (deficiency)	133	29
Military Academy (for building and grounds)	40	26
Post-Office Department (deficiency)	120	29
Public Printing (deficiency)	136	29
Arapahoe and Shoshone Indians, letter of Secretary of Interior relative to negotiations with	51	26
Armor contracts, letter of Secretary of Navy relative to violation of (parts 1 and 2)	160	29
Arms, etc., overdrawn, letter of Secretary of War relative to	187	29
Army, letter of Secretary of War transmitting draft of bill to promote administration of justice in	60	26
sundry communications relative to rank and allowance of veterinarians of	119	29
statement of expenditures for contingent expenses of	122	29
Assistant Attorneys, letter of Secretary of Treasury transmitting estimate of deficiency in appropriation for pay of	184	29
Attorney-General, letter of Secretary transmitting estimate to print opinions of	117	29
Communications from—		
Campbell, W. M., recalling recommendation of appropriation for	229	29
Central and Western Pacific Railroad companies, relative to information requested of liability of, to the Government	205	29
Department of Justice, relative to efficiency of employees in	21	26
Indian Territory, transmitting report from United States attorney of methods of trying misdemeanors in	67	26

Subject.	No.	Vol.
Attorney-General—Continued.		
Communications from—		
International Penitentiary Congress, transmitting papers relating to participation in	156	29
Judgments, transmitting report on, obtained against United States	59	26
supplemental list	242	29
Union Pacific Railway, letter relative to appointment of receivers for, etc	194	29
transmitting a draft of bill to secure claim of United States against	203	29
B.		
Baltimore Naval Veteran Association, letter of Secretary of War relative to bill to donate condemned cannon to	180	29
Big Sandy River, Kentucky, letter of Secretary of War submitting estimate for completing at Louisa, Ky	78	26
Board of Ordnance and Fortification, third report of	23	26
Boston navy-yard, letter of Secretary of Treasury transmitting estimate for heating marine barracks at	54	26
Brockway, Benjamin L., letter of Secretary of Navy relative to appointment of, to Naval Academy	94	26
Buffalo, N. Y., letter of Secretary of Treasury relative to item for public building at	144	29
Bureau of American Republics, estimate to maintain and continue work of	124	29
Bureau of Statistics, report on imported merchandise, 1890–1893 (H. Mis. Doc. 96)		25
letter of Secretary of Treasury transmitting report of chief of, on the principal imports and exports, etc	71	26
report on useless papers in	208	29
C.		
California Débris Commission, letter of Secretary of War relative to certain changes in law relating to	132	29
Campbell, W. M., letter of Attorney-General recalling recommendation for appropriation for	229	29
Carnegie, Phipps & Co. (*See* Armor Contracts.)		
Carnot. (*See* President of French Republic.)		
Case, Samuel, letter of Secretary of Treasury transmitting papers relating to claim of	58	26
California Débris Commission, letter of Secretary of War transmitting report of	16	26
Caswell, T. T., letter of Secretary of Navy relative to accounts of	232	29
Central Pacific Railroad Company, letter of Secretary of Treasury transmitting transportation claims of	168	29
Chandeleur, La., letter of Secretary of Treasury relative to reestablishing light station at	225	29
Charleston, S. C., letter of Secretary of Treasury showing necessity for additional lights in harbor of	260	29
Cherokee, N. C., letter of Secretary of Treasury transmitting estimate of appropriation for support of Indian school at	142 175	29 29
Cherokee Outlet, letter of Secretary of Treasury transmitting estimates for removal of intruders from	26	26
Chicago, Ill:		
Letter of Secretary of War transmitting estimate for payment of work done on approaches of marine hospital at	115	29
Letter of Postmaster-General transmitting papers in claim of	202	29
Chinese exclusion act, letter of Secretary of Treasury submitting estimate to enforce	86	26
registration, letter of Secretary of Treasury transmitting request for increase of appropriation for	152	29

Subject.	No.	Vol.
Civil Service Commission, annual report of, part 8 of No. 1	------	21
Civilian engineers, report of Secretary of War on, employed in river and harbor work	29	26
Claims:		
Letter of Secretary of the Treasury transmitting list of, allowed by accounting officers	93	26
Letter carriers, statement of Postmaster-General relative to, of	8	26
Clay, Cecil, letter of Secretary of Treasury transmitting communication relative to expenses of, in matter of sale of certain lands near Fort Mifflin, Pa	100	29
Coast and Geodetic Survey, letter of Secretary of Treasury transmitting statement of expenditures of (1893)	157	29
Cœur d'Alene Indians, letter of Secretary of Interior transmitting agreement with	158	29
Colored soldiers, letter of Secretary of Treasury transmitting report of arrears of pay, etc., due estates of deceased	258	29
Columbia Arsenal, estimate of deficiency appropriation for	181	29
Colville Reservation, letter of Secretary of Treasury transmitting estimates of deficiency for opening	238	29
Commercial relations, annual report of U. S. consuls on	83	28
Commissioners of the District of Columbia, annual report of	------	20
Commissioner of Internal Revenue, annual report of	4	21
Commissioner of Labor:		
Ninth annual report of, 1893	------	30
Special report on slums of cities	------	31
Commissioner of Railroads, letter of Secretary of Treasury transmitting communication from, relating to increase of estimate for traveling expenses	64	26
Comptroller of Currency, annual report of, 1893 (two parts)	------	23
Comptroller of Treasury, letter of, transmitting report relative to delinquent officials	34	26
Congaree River, letter of Secretary of War relative to improvement of	66	26
Consular reports, annual report of consuls on commercial relations	83	28
Consular regulations, letter of Secretary of Treasury transmitting estimates to rewrite	104	29
Court of Claims, letter of Secretary of Treasury transmitting list of judgments of Court of Claims for which there is no appropriation	102	29
Courts of United States:		
Letter of Secretary transmitting estimate of deficiency for payment of witnesses	68	26
Bailiffs, etc., deficiency estimate	201	29
Deficiency estimates by Secretary of Treasury	211 230	29 29
Letter of Postmaster-General relative to change of the rule of evidence in, relating to handwriting	196	29
Letter of Secretary of Treasury transmitting additional list of amounts found due, etc	159	29
Letter from Secretary of Treasury transmitting request for additional appropriation for	167	29
Crawfish Creek, Ohio, letter of Secretary of War transmitting report on	24	26
Crow Creek Reservation, letter of Secretary of Treasury transmitting estimate to pay Indians on, etc	121	29
Currency, annual report of Comptroller on the (two parts)	------	23
Customs duties, letter of Secretary of Treasury submitting estimates for collecting	52	26
letter of Secretary of Treasury transmitting detail statement of refunds of	110	29
Customs officers, letter of Secretary of War transmitting abstract of emoluments of	114	29
Customs service, report of Secretary of Treasury on awards of moieties to informers in	85	26
letter of Secretary of Treasury relative to payment of officers after expiration of commissions	150	29

Subject.	No.	Vol.
Customs service, report of collection for the World's Columbian Exposition	165	29
letter of Secretary of Treasury submitting estimate of deficiency for collecting duties	231	29
D.		
Deal, Charles, letter of Secretary of Treasury relative to claim of	185	29
Deficiencies (*see* also appropriations), letters of Secretary transmitting estimates of, for the several Departments	33	24
	103	24
Delinquent officials, letter of Comptroller of Treasury transmitting report on	34	26
Department of Agriculture, letter of Secretary of Agriculture relative to expenses of	14	26
letter of Secretary of Treasury transmitting estimate of deficiency for vegetable pathological investigation, etc	236	29
report on special agents employed by	243	29
Department of the Interior, estimate of deficiencies in appropriations for	38	26
letter of Secretary of Interior relative to contingent expenses of	50	26
letter of Secretary of Treasury transmitting estimate of deficiency for printing and binding for	235	29
Department of Justice, letter of Attorney-General submitting report on efficiency of employés in	21	26
letter of Secretary of Treasury transmitting deficiency estimates	126	29
Department of State, letter of Secretary of Treasury transmitting estimate of deficiency for printing and binding for	172	29
Diplomatic and consular service, letter of Secretary of Treasury transmitting estimate for contingent expenses for foreign missions	118	29
Director of Mint, report on productions of precious metals for 1893	237	29
District of Columbia, annul report of Commissioners of	------	20
letter of Secretary of Treasury relative to deficiencies in appropriations for	189	29
Aqueduct bridge, letter of Secretary of Treasury transmitting estimate for repair of	73	26
letter of Secretary of Treasury transmitting additional estimate of appropriation for employés in court-house	45	26
letter of Secretary of Treasury transmitting recommendation for increase of compensation to assistant U. S. attorney for	65	26
public schools, estimate for contingent expenses of	222	29
sewer from Fifteenth and E streets, letter of Secretary of Treasury transmitting estimate to complete	73	26
letter of Secretary of Treasury transmitting communication from Treasurer of United States relative to bill (H. R. 6167) relative to payment of greenback certificates of	169	29
E.		
Eastern Band of Cherokee Indians, letter of Secretary of Treasury transmitting agreement of compromise, etc	128	29
Educational report for 1893	------	18
Eleventh Census, letter of Secretary of Treasury transmitting estimate of appropriation for	44	26

Subject.	No.	Vol.
Emigrants, letter of Secretary of Treasury transmitting draft of bill to determine movement, etc	239	29
Engineer's report, parts 1 to 6, vols. 3, 4, 5, 6, 7, 8	------	------
F.		
Finance report, 1893	------	22
Fish Commission, letter of Secretary of Treasury transmitting estimate of appropriation for	35	26
First Comptroller. (*See* Treasurer of United States.)		
Fond du Lac Indians, letter of Secretary of Treasury transmitting estimate for	55	26
Ford Theater building, letter of Secretary of War transmitting report on condition of	61	26
Foreign commerce and navigation of United States, report on, (two parts)	------	25
Foreign missions, letter of Secretary of Treasury transmitting estimate for contingent expenses for	118	29
Fort Hall Reservation, letter of Secretary of Treasury transmitting estimate of deficiency for surveying a portion of	161	29
Fort Leavenworth, Kans., letter of Secretary of War relative to general service clerk for infantry and artillery school at	27	26
letter of Secretary of Treasury transmitting estimates for additional appropriations for military prison at	88	26
letter of Secretary of Treasury transmitting estimate of deficiency for support of military prison at	153	29
Fort Monroe, Va., letter of Secretary of War relative to general service clerk for infantry and artillery school at	27	26
letter of Secretary of War relative to occupation of public lands at	46	26
Fort Riley, Kans., letter of Secretary of Treasury transmitting estimate for artillery and cavalry school at	56	26
Fort Shaw, Mont., letter of Secretary of Treasury transmitting estimate of appropriation for support of Indian school at	176	29
Fortification appropriation bill, letter of Secretary of War transmitting amendment to	82	26
French Republic. (*See* President of French Republic.)		
G.		
General Land Office, letter of Secretary of Treasury transmitting estimate for engraving maps of United States for	17	26
letter of Secretary of Treasury transmitting estimates for reproducing plats of surveys for	74	26
Geological Survey for 1893, part 1	------	16
part 2	------	17
Gleason, Andrew, letter of Secretary of Treasury relative to judgment of	183	29
Government, letter of Secretary of Treasury transmitting detailed statement of receipts and expenditures of the	42	26
letter of Attorney-General transmitting list of judgments against	59	26
Government Printing Office, letter of Secretary of Treasury transmitting estimate for removal and storage of certain material	134	29
estimates of deficiency for	234	29
Graham, J. J., letter of Secretary of Treasury transmitting estimates to pay for services	228	29

Subject.	No.	Vol.
Grand Army of Republic, letter of Secretary of War transmitting supplementary statement relative to encampment at Washington	28	26
Great Lakes, letter of Secretary of War transmitting report on raft towing on	22	26
Greek Church of Alaska, letter of Secretary of Treasury relative to reimbursing bishop of	164	29
H.		
Harbors, letter of Secretary of War relative to damage of, by dumping	123	29
Hawaii:		
President's message relating to	47	27
President's message relating to (correspondence)	48	27
Letter of President transmitting certain further information relating to	70	27
Letter of President transmitting further correspondence relating to	76	27
Letter of President transmitting further correspondence relating to	79	27
Letter of President transmitting dispatch of U. S. minister	95	27
Letter of President transmitting further correspondence	112	27
Letter of Secretary of Navy relative to use of U. S. naval force at	140	27
Letter of President transmitting dispatches from U. S. minister at	256	27
Hay Lake Channel, letter of Secretary of Treasury recommending lighting of	127	29
Hitt, J. J., *et al.*, letter of Secretary of Treasury transmitting estimates to pay for legal services	92	26
Hudson, N. Y., letter of Postmaster-General transmitting papers in case of postmaster at	109	29
Hudson River bridge, veto of bill	81	26
I.		
Immigration and contract-labor laws, report of by Secretary of Treasury, as requested by House resolution	247	29
Immigration and passenger movement at ports of United States (Ex. Doc. 6, part 2)	------	25
Imported merchandise, 1890–1893 (Mis. Doc. 96)	------	25
Imports and exports, letter of Secretary of Treasury transmitting report of Chief of Bureau of Statistics, on the principal	71	26
Indian appropriation bill, letter of Secretary of Treasury transmitting recommendation for amendment to	87	26
letter of Secretary of Treasury submitting amendment to section 2 of	255	29
Indian Department, tabular statement of disbursements for	36	26
Indian schools, letter of Secretary of Treasury transmitting communication relative to assistant for superintendent of	105	29
Indian Territory, letter of Attorney-General transmitting report of method of trying misdemeanors in	67	26
Indian Department. (*See* Department of Interior.)		
Intercontinental Railway Commission, letter of Secretary of Treasury relative to compensation of United States representative on	15	26
International Penitentiary Congress, letter of Attorney-General relative to participation in	156	29
Interstate Commerce Commission, letter of Secretary of Treasury transmitting letter of, relative to reappropriation of unexpended balances	41	26
Iron and steel tests, report on, at Watertown Arsenal	43	26
J.		
Johnson, Charles, letter of Secretary of Treasury transmitting statement of losses of	177	29
Johnson, J. W., letter of Postmaster-General transmitting papers in claim of	109	29

Subject.	No.	Vol.
Jones, W. C., letter of Secretary relative to payment of	125	29
Judgments, report of Attorney-General on, against United States	59	26
(Supplemental list)	242	29
K.		
Kelly, E. P., letter of Secretary of Treasury transmitting estimates to pay	228	29
L.		
Land entries. (*See* Public lands.)		
Land Office. (*See* General Land Office.)		
Larkin, G. T., letter of Secretary of Treasury transmitting claim of	214	29
Leases, letter of Secretary of War regarding, granted in 1893	89	26
Letter carriers, letter of Postmaster-General relative to claims of	8	26
Liberty statue, letter of Secretary of Treasury relative to light on	116	29
Light-house employés, letters of Secretary of Treasury relative to loss of certain, by storms of 1893	9	26
	10	26
	11	26
	91	26
Lights, letters relative to, at:		
Chandeleur, La	225	29
Charleston, S. C	260	29
Lower Cedar Point, Maryland	154	29
Sandusky Bay (repair)	241	29
Smith Pass, Mississippi River	218	29
Tampa Bay, Florida	246	29
Lower Cedar Point, Maryland, letter of Secretary of Treasury transmitting estimate to rebuild light-house at	154	29
Loy, D. S., letter of Secretary of Treasury relative to claim of	18	26
M.		
McCoy, J. G., letter of Secretary of Treasury relative to pay of	182	29
Machine guns, letter of Secretary of Treasury transmitting estimate of appropriation to purchase	130	29
Mahony, Patrick, letter of Secretary of Treasury relative to judgment of	183	29
Marine Corps, letter of Secretary of Treasury transmitting estimate of deficiency for clothing	133	29
Merchandise, report on imported merchandise for 1890–93 (House Mis. Doc. 96)		25
Militia, letter of Secretary of War transmitting abstract of militia force of United States	101	29
Military Academy, letter of Secretary of War transmitting communication relative to asphalt walks at	162	29
letter of Secretary of Treasury transmitting estimate of appropriation for buildings and grounds for	40	26
Military establishment. (*See* Army.)		
Mill Creek, Ohio, letter of Secretary of War transmitting report on	24	26
Minnesota River, letter of Secretary of War transmitting report on	249	29
Mississippi River, letter of Secretary of Treasury transmitting recommendation relative to lights at mouth of	218	29
letter of Secretary of War transmitting estimates for improvement of, under Mississippi River Commission	20	26
Missouri River, letter of Secretary of War transmitting estimates for improvement of, under Missouri River Commission	20	26
letter of Secretary of War transmitting report of survey, etc., of, from Three Forks to Canyon Ferry, Mont	96	26

Subject.	No.	Vol.
Money orders. (*See* Post-Office Department.)		
Moore, Ely, statement of amount found due to	221	29
Mount Pleasant (Mich.) Indian school, letter of Secretary of Treasury transmitting increase of estimate for	151	29
Mystic (steamer), letter of Secretary of Secretary of War transmitting statements, etc., of burning of	129	29
N.		
Naval Observatory, letter of Secretary of Treasury transmitting estimate of deficiency in appropriation for contingent expenses of	210	29
Navy Department, letter of Secretary of the Navy transmitting list of employés in	90	26
Nebeker, E. H., letter of Secretary of Treasury relative to reimbursement of	98	29
New Mexico, letter of Secretary of Interior transmitting copies of journal and laws of	62	26
New Orleans, letter of Secretary of Treasury relative to pay of certain mint employés at	195	29
New York Harbor, letter of Secretary of War transmitting report relative to dumping in	57	26
letter of Secretary of War on subject of injurious deposits in	143	29
Norfolk navy-yard, letter of Secretary of Treasury transmitting estimate for fireproof storeroom at	99	29
letter of Secretary of Treasury transmitting estimate for replacing certain store destroyed by fire at	108	29
North American Commercial Company, transmitting papers in case of claim of	186	29
North Carolina, letter of Secretary of Treasury transmitting communication relative to survey of certain land in	105	29
O.		
Oklahoma, letter of Secretary of Interior transmitting journals of first session of legislature of	32	26
letter of Secretary of Interior transmitting copies of laws of	69	26
letter of Secretary of Treasury transmitting estimate to pay certain deputy marshals in	107	29
claim of W. C. Jones for services and expenses for opening up of	125	29
Olsen, H. J. G., letter of Secretary of Treasury transmitting affidavit of	138	29
Ordnance and Fortification, third report of Board of	23	21
Owensby, J. C., letter of Secretary of Treasury transmitting papers in claim of	212	29
P.		
Pacific railroads, letter of Secretary of Interior in response to resolution of House for information as to sinking fund of, to redeem bonds issued for	206	29
Pacific railroads, Central and Western, message of Attorney-General in response to House resolution for information relating to liability of, to the Government	205	29
Page, Henry, letter of Secretary of Treasury relating to claim of	220	29
Passengers. (*See* Emigrants.)		
Patent Office, letter of Secretary of Treasury transmitting recommendation for a classification division in and appropriation for the scientific library in	190	29
Pensions, letter of Secretary of Interior transmitting certain information relative to complying with act of December 21, 1893	135	29

Subject.	No.	Vol.
Petoskey Harbor, Michigan, letter of Secretary of War relative to item in river and harbor bill for improvement of	193	29
Phœnix (Ariz.) Indian school, letter of Secretary of Treasury transmitting estimate for	163	29
Philadelphia, letter of Secretary of Treasury transmitting estimate for reconstructing bulkhead at Naval Home at	204	29
letter of Secretary of Treasury concerning site for mint at	233	29
Pittsburg, Pa., letter of Secretary of Treasury transmitting estimate to cover expense of sale of certain lands at	137	29
Postage stamps, letter of Secretary of Treasury on subject of bid for printing of	141	29
letter of Postmaster-General relative to contract to print	223	29
Postal service, letter of Secretary of Treasury transmitting estimates of deficiencies for	111	29
Postal notes. (*See* Post-Office Department.)		
Postmaster-General:		
Communications from—		
Annual report of		12
Chicago postmaster, transmitting papers in claim of	202	29
Evidences, relative to change of rule of, relative to handwriting comparison	196	29
Johnson, J. M., transmitting papers in claim of	109	29
Letter carriers, relative to claims of	8	26
Postage stamps, transmitting information relative to contract to furnish	223	29
Railway Mail Service, transmitting list of dismissals in 1889, Mar. 4 to May 1	244	29
Tucker, Irwin, transmitting papers in case of	178	29
Post-Office Department, letter of Secretary of Treasury transmitting deficiency estimates for	120	29
letters of Secretary of Treasury, transmitting recommendation to limit validity of postal notes and money orders to 10 years	200	29
Potomac Flats, letter of Secretary of War transmitting report on	113	29
Precious metals, report of Director of Mint on production of (1893)	237	28
President of French Republic, letter of Secretary of State relating to religious services at St. Matthew's Church	245	29
letter of Secretary of State, transmitting notice from French minister of foreign affairs relating to resolution passed by Congress of United States on death of	252	29
President of the United States:		
Communications from—		
Annual message and foreign relations	1	1
Hawaii	47	27
(correspondence)	48	27
transmitting certain further information, etc	70	27
transmitting further correspondence relating to	76	27
	79	27
transmitting dispatch received from U. S. minister	95	27
transmitting further correspondence	112	27
letter transmitting dispatches from U. S. minister at	256	27
Veto, bill H. R. 71, relating to relief of purchasers of stone and timber lands	75	26
Hudson River bridge (H. R. 3289)	81	26
Eugene Wells	259	29
Printing. (*See* Public printing.)		
Pima Agency, Ariz., estimate for flour mill at	227	29
Public buildings, letter of Secretary of the Treasury relative to plans, specifications, etc	179	29

Subject.	No.	Vol.
Public lands, letter of President returning with objection bill H. R. 71, relating to purchasers of timber and stone lands	75	26
letter of Secretary of Interior, transmitting abstract of suspended entries	84	26
Public Printer, estimates of deficiency in appropriations for	234	29
Public printing and binding, letter of Secretary of Treasury relative to deficiencies in appropriations for	25	26
Public printing, letter of Secretary of Treasury transmitting estimate of deficiency for	136	29
Public property, letter of Secretary of Treasury, transmitting statement of unoccupied and unproductive public property	252	29
Q.		
Quartermaster-General, letter of Secretary of War transmitting annual report of	30	26
R.		
Railway Mail Service, letter of Postmaster-General relative to removals of clerks in 1889	244	29
Raft towing. (*See* Great Lakes.)		
Receipts and expenditures of United States, annual statement of	42	26
Record and Pension Division. (*See* War Department.)		
Revenue steamers, letter of Secretary of Treasury transmitting estimate of appropriation for construction of	19	26
Rivers and harbors, report of Secretary of War on civilian engineers employed on works of	29	26
S.		
St. Johnsbury, Vt., letter of Secretary of Treasury transmitting estimate of deficiencies for fish-culture station at	146	29
St. Marys Falls Canal, Michigan, letter of Secretary of War transmitting report relative to commerce passing through	49	26
letter of Secretary of War transmitting report on	224	29
St. Marys River, letter of Secretary of Treasury relative to appropriation for lighting Hay Lake channel of	127	29
Sandusky Bay, letter of Secretaryof Treasury recommending repair of range lights in	241	29
Sandy Hook, letter of Secretary of Treasury transmitting estimate for sea wall at	145	29
letter of Secretary of Treasury transmitting estimate to build sea-wall at	217	29
Santiago (Chile) Exposition, letter of Secretary of Treasury transmitting papers relative to participation of United States in	147	29
Saugatuck Harbor, Michigan, letter of Secretary of War transmitting report on	248	29
letter of Secretary of War transmitting survey of	261	29
Seal fisheries, letter of Secretary of Treasury suggesting appropriation for inspectors at San Francisco and Victoria	254	29
Secretary of Agriculture:		
Communications from—		
Annual report of	------	19
Department of Agriculture, relative to expenses of	14	26
Special agents, report on, in response to House resolution, employed by Department of Agriculture	243	29
Secretary of the Interior:		
Communications from—		
Annual report of, vols. 13, 14, 15	------	------
report of director of Geological Survey, vols. 16 and 17	------	------

Subject.	No.	Vol.
Secretary of the Interior—Continued.		
Communications from—		
Annual report of Commissioner of Education	------	18
Coeur d'Alene Indians, transmitting agreement with	158	29
Indian department, transmitting report on disbursements for	36	26
Interior Department, transmitting statement of contingent expenses of	50	26
New Mexico, transmitting copies of laws and journal of legislature of	62	26
Oklahoma, transmitting journals of first session of legislature of	32	26
transmitting copies of laws of	69	26
Pacific railroads, response to House resolution for information relative to payment by, of bonds issued to aid construction of	206	29
Pensions, transmitting information relative to complying with act of Dec. 21, 1893	135	29
Public lands, transmitting abstract of suspended entries	84	26
Shoshone and Arapahoe Indians, transmitting letters of Commissioner of Indian Affairs relative to certain negotiations with	51	29
Tennessee: transmitting letter of Commissioner of Education relative to attack on educational institutions of	173	29
Yankton Sioux Indians, transmitting papers relative to ratification of treaty with	80	26
Secretary of the Navy:		
Communications from—		
Annual report	------	11
Armor contracts, relative to violation of (parts 1 and 2)	160	29
Brockway, B. L., transmitting papers regarding appointment of to Naval Academy	94	26
Hawaii, transmitting information relative to use of United States naval forces at	140	29
Navy Department, transmitting list of employés in	90	26
Secretary of State:		
Communications from—		
Foreign relations of United States	1	1
President of French Republic, informing House of Representatives of religious services, etc	245	29
transmitting dispatch relating to reception of resolutions on death of, passed by Congress	252	29
Secretary of the Treasury:		
Communications from—		
Annual report on finances	------	22
Adjutant-General, transmitting estimate for contingent expenses of	155	29
African slave trade, transmitting estimate to cover part of expenses of special bureau relating to	72	26
Alaska, transmitting estimate for improvements at Seal Island	207	29
Alaska salmon fisheries, recommending item for protection of	215	29
Appropriations, book of estimates of	5	24
transmitting estimates of deficiencies in	33	24
	103	24
Assistant attorneys, transmitting estimates of deficiency in appropriations for pay of	184	29
Assistant treasurers, transmitting request for increased force for, in Chicago, St. Louis, and New Orleans	216	29
Attorney-General, transmitting estimates to print decisions of	117	29
Boston navy-yard, transmitting estimate for heating marine barracks at	54	26
Buffalo (N. Y.) public building, requesting item for continuation of work on	144	29
Bureau of American Republics, transmitting estimate for maintenance of, etc	124	29
Case, Samuel, transmitting papers in case of claim of	58	26
Caswell, T. T., transmitting recommendation relative to accounts of	232	29

Subject.	No.	Vol.
Secretary of the Treasury—Continued.		
Communications from—		
Chandeleur, La., recommending reestablishment of light station at	225	29
Charleston, S. C., showing necessity for additional lights in harbor	260	29
Cherokee (N. C.) Indian school, transmitting revised estimate for	142	29
Cherokee Outlet, transmitting estimate of appropriation for removal of intruders from	26	26
Chicago, Ill., transmitting estimate from Supervising Architect for payment of work in connection with marine hospitals at	115	29
Chile Exposition, transmitting papers, etc., relative to	147	29
Chinese exclusion act, submitting estimate to enforce	86	26
Chinese registration, transmitting request for increase of appropriation for	152	29
Clay, Cecil, transmitting estimate of expenses in sale of land near Fort Mifflin, Pa	100	29
Claims, transmitting list of, allowed by accounting officers	93	26
Coast and Geodetic Survey, transmitting statement of expenditures of (1893)	157	29
Colored soldiers, transmitting information relative to arrears of pay, etc., due estates of deceased	258	29
Colville Reservation, transmitting estimate of deficiency for opening	238	29
Commissioner of Railroads, transmitiing communication relative to traveling expenses of	64	26
Consular Regulations, transmitting estimate for having rewritten	104	29
Court of Claims, transmitting list of judgments rendered by, etc.	102	29
Courts of United States, transmitting estimates of deficiency for payment of witnesses in	68	26
transmitting request for additional appropriation for	167	29
transmitting additional list of amounts found due, etc	159	29
transmitting estimates of deficiency for	211	29
deficiency estimates to pay bailiffs, etc.	201	29
deficiency estimates	230	29
Crow Creek Reservation, transmitting estimate to pay Indians in, etc	121	29
Customs duties, transmitting estimate for collecting	52	26
transmitting report of awards to informers	85	26
transmitting detailed statement of refunds of	110	29
Customs officers, transmitting report on emoluments of	114	29
Customs Service, transmitting communication relative to payment of officers in, after expiration of term of service	150	29
transmitting estimate of deficiency to collect revenue from customs	231	29
Deal, Charles, relative to claim of	185	29
Deficiencies in appropriations, transmitting estimates of	103	24
Department of Agriculture, transmitting item of deficiency for investigations, etc	236	29
Department of Justice, transmitting deficiency estimate for	126	29
Department of State, transmitting estimate of deficiency for printing and binding in	172	29
District of Columbia, transmitting additional estimates of appropriation for certain employés in courthouse of	45	26
transmitting recommendation for increase of compensation of assistant to U. S. attorney for	65	26
transmitting estimate to complete sewer from Fifteenth and E streets to Potomac River, and repair of Aqueduct Bridge	73	26

Subject.	No.	Vol.
Secretary of the Treasury—Continued.		
Communications from—		
District of Columbia, relative to deficiencies in appropriations for	189	29
estimate for contingent expenses of public schools	222	29
Eastern Band of Cherokee Indians, transmitting agreement of compromise of, etc	128	29
Eleventh Census, transmitting estimate of appropriation for	44	26
Emigrants, transmitting draft of bill relating to	239	29
Fish Commission, transmitting estimate of appropriation for	35	26
Fond du Lac Indians, transmitting estimate for	55	26
Foreign commerce and navigation of United States (two parts)	------	25
Foreign missions, transmitting estimate for contingent expenses of	118	29
Fort Hall Reservation, transmitting estimate of deficiency for surveying a portion of	161	29
Fort Leavenworth, Kans., transmitting additional estimate for military prison at	88	26
transmitting estimate of deficiency for support of military prison at	153	29
Fort Riley, Kans., transmitting estimate for artillery and cavalry school at	56	26
Fortification appropriation bill, transmitting amendment to	82	26
Gleason, Andrew, relative to judgment of	183	29
Government Printing Office, transmitting estimate for removal and storage, etc	134	29
Graham, J. J., transmitting estimates to pay	228	29
Greek Church of Alaska, recommending appropriation to reimburse bishop of	164	29
Greenback certificates of District of Columbia, transmitting letter of Treasurer relative to bill (H. R. 6177) relating to	169	29
Hay Lake channel, St. Mary's River, relative to appropriation for lighting	127	29
Hitt, J. J., *et al.*, transmitting estimate to pay for legal services	92	26
Immigration and contract labor laws, transmitting information as to administration of	247	29
Immigration and passenger movement at ports of United States (Ex. Doc. 6, part 2)	------	25
Imports and exports, etc., letter transmitting report of Chief of Bureau of Statistics on principal	71	26
Indian appropriation bill, transmitting recommendation for amendment to	87	26
submitting amendment to section 2 of	255	29
Indian school at Cherokee, N. C., transmitting estimate of appropriation for	175	29
Indian school at Fort Shaw, Mont., transmitting estimate of appropriation for	176	29
Indian schools, transmitting communication relative to assistant to superintendent of	105	29
Intercontinental Railway Commission, relative to compensation for U. S. representatives on	15	26
Interior Department, transmitting estimates of deficiencies in appropriations for	37	26
estimate of deficiency for printing and binding for	235	29
Interstate Commerce Commission, transmitting letter relative to reappropriation of certain unexpended balances	41	26
Johnson, Charles, transmitting statement of losses of	177	29
Jones, W. C., transmitting estimate of expenses, etc., in opening up Oklahoma	125	29
Kelly, E. P., transmitting estimate to pay	228	29
Land Office maps, transmitting estimate for engraving	17	26
Land Office surveys, transmitting estimate to reproduce plats of	74	26
Larkin, G. T., transmitting papers relating to claim of	214	29

Subject.	No.	Vol.
Secretary of the Treasury—Continued.		
Communications from—		
Liberty statue, relative to light on	116	29
Light-house employés, relative to losses by in storm of 1893	9	26
	10	
	11	
	91	
Lower Cedar Point, Maryland, transmitting estimate to rebuild light-house at	154	29
Loy, D. S., transmitting estimate for appropriation for	18	26
Machine guns, transmitting estimates to purchase	130	29
McCoy, J. G., transmitting communication relative to pay of	182	29
Mahony, Patrick, relative to judgment of	183	29
Marine Corps, transmitting estimates of deficiency for clothing	133	29
Military academy, letter of Secretary of Treasury transmitting additional estimate for buildings and grounds	40	26
Mint at Philadelphia, transmitting information concerning securing site for	233	29
Mississippi River, transmitting estimate to establish light-ship at South Pass of	218	29
Moore, Ely, transmitting report of amounts due	221	29
Mount Pleasant (Mich.) Indian school, transmitting increased estimates for	151	29
Naval Observatory, transmitting estimate of deficiency for contingent expenses of	210	29
Nebecker, E. H., transmitting communication relative to reimbursement of	98	29
New Orleans mint, relative to pay of certain employés in	195	29
Norfolk navy-yard, Va., transmitting estimate for fire-proof storehouse	99	29
transmitting estimate for replacing certain store destroyed by fire	108	29
North American Commercial Company, transmitting papers in case of claim of	186	29
North Carolina, transmitting communication relative to survey of land in	106	29
Oklahoma, transmitting estimate to pay certain deputy marshals in	107	29
Olsen, H. J. G., transmitting statement of, relative to losses, etc	138	29
Owensby, J. C., transmitting papers in claim of	212	29
Page, Henry, transmitting papers in case of	220	29
Patent Office, relative to appropriations for classification divisions in, and for the scientific library of	190	29
Philadelphia, transmitting estimate relating to reconstruction of bulkhead at Naval Home	204	29
Phœnix (Ariz.) Indian School, transmitting estimates for	163	29
Pima Agency, Ariz., transmitting recommendation for appropriation for flour mill at	227	29
Pittsburg, Pa., transmitting estimate to meet expense of sale of certain lands at	137	29
Postage stamps, transmitting information relative to proposal of Bureau of Printing and Engraving, etc	141	29
Postal Service, transmitting estimates of deficiencies for	111	29
Post-Office Department, transmitting deficiency estimate for	120	29
relative to limitation of time of payment of postal notes and money orders	200	29
Public buildings, relative to plans, specifications, etc., of	179	29
Public printing, etc., transmitting estimate of deficiency for	25	26
	136	29
	234	29
Public property, transmitting tabulated statement of unoccupied and unproductive public property of United States	252	29
Receipts and expenditures of United States, transmitting detailed statement of	42	26

Subject.	No.	Vol.
Secretary of the Treasury—Continued.		
Communications from—		
Revenue steamers, transmitting estimates of appropriation for construction of	19	26
St. Johnsbury, Vt., transmitting estimate of deficiencies for fish-cultural station at	146	29
Sandusky Bay, recommending appropriation for repairs of range lights in	241	29
Sandy Hook, transmitting estimates for sea wall at	145	29
	217	29
Seal fisheries, suggesting appropriations for inspectors at Victoria and San Francisco	254	29
Secret Service, transmitting request for additional appropriation for	166	29
Shoshone Agency, Wyo., transmitting estimate for erection of flour mill and sawmill at	77	26
Sioux Falls, S. Dak., referring to estimate for completion of public building at	240	29
Southern and Central Pacific railroads, transmitting schedule of claims of	168	29
Statistical Abstract for 1893	97	28
Statistical abstract of foreign countries, transmitting request of Chief of Bureau of Statistics for authority to print	198	29
Steamship, relative to bill to facilitate entry of	191	29
Supervisors of elections, transmitting request for appropriation to pay certain	148	29
Supreme Court, transmitting estimate of deficiency for printing and binding for	149	29
Tampa Bay lights, recommending increase of appropriation for	246	29
Treasurer of United States, transmitting estimate for additional clerk in office of assistant, at Cincinnati	226	29
Deficiency in appropriations for contingent expenses, Independent Treasury	197	29
Transmitting estimate of deficiency to pay special agents	219	29
Treasury bindery, relative to machinery for	170	29
Treasury Department, relative to contingent expenses of	13	26
transmitting schedules of useless papers in (2 parts)	208	29
Treasury notes, relative to 7.3 per cent notes	188	29
Umpqua River light station, transmitting estimate for finishing	131	29
Vessels, transmitting bill to amend section 5294 of Revised Statutes, relating to	251	29
White, J. K., transmitting claim of	53	26
Winston, Alexander M., relative to claim of	171	29
Woodson, Daniel, transmitting report of amounts due	221	29
World's Columbian Exposition, transmitting report of collector of customs for	165	29
War Department, letter of Secretary of Treasury relative to rent of building for Record and Pension Division of	192	29
Record and Pension Division, transmitting estimate for rent of Union Building for	213	29
Yuen, Sam, transmitting papers in case of	174	29
Secretary of War:		
Communications from—		
Annual message (part 2 of President's message, and accompanying documents)	------	2
Arms, etc., overdrawn, relative to	187	29
Army, transmitting draft of bill to promote administration of justice in	60	29
transmitting report on contingent expenses of	122	29
Baltimore Naval Veterans' Association, relative to bill to donate condemned cannon to	181	29
Board of Ordnance and Fortification, third report of	23	26

Subject.	No.	Vol.
Secretary of War—Continued.		
Communications from—		
California Débris Commission, transmitting report of	16	26
transmitting letter of President of, relating to certain modifications of act creating	132	29
Chief of Ordnance, report of	------	9
Civilian engineers, transmitting statement of, employed in river and harbor work	28	26
Engineer's report, parts 1 to 6	------	3–8
Fort Leavenworth, relative to general-service clerk for infantry and artillery school at	27	26
Fort Monroe, Va., referring to occupation of public lands at	46	26
relative to general-service clerk for infantry and artillery school at	27	26
Ford Theater building, transmitting report on condition of	61	26
General service clerks, submitting paper relative to, at Fort Leavenworth, Kans., and Fort Monroe, Va	27	26
Grand Army of the Republic encampment, transmitting supplemental requisition by citizens' committee for	28	26
Great Lakes, transmitting report on raft towing on	22	26
Harbors, transmitting report on damage by dumping, etc	123	29
Inspector-General, report of	------	10
Leases, transmitting list of, granted in 1893	89	26
Militia, transmitting abstract of militia force of United States	101	29
Military Academy, transmitting communication relative to asphalt walks at	162	29
Mystic (steamer), transmitting letter relative to losses by burning of	129	29
New York Harbor, transmitting report relative to dumping in	57	26
Potomac Flats, transmitting report relative to	113	29
Quartermaster-General, transmitting annual report of	30	26
Rivers and harbors—		
Big Sandy River, Kentucky	78	26
Congaree River	66	26
Crawfish Creek, Ohio	24	26
Mill Creek, Ohio	24	26
Minnesota River, Minnesota	249	29
Mississippi River from Passes to mouth of Ohio River	20	26
Missouri River from its mouth to Sioux City, Iowa	20	26
between Three Forks and Canyon Ferry, Mont	96	26
New York Harbor, injurious deposits in	143	29
Petoskey (Mich.) Harbor, transmitting letter relative to item in river and harbor appropriation bill relative to	193	29
St. Marys Fall Canal, relative to commerce passing through	49	26
relative to improvement of	224	29
Saugatuck Harbor, Michigan	248	29
	261	29
Soldiers' Home, transmitting draft of bill to regulate admission to	38	26
Tests of iron and steel at Watertown Arsenal, transmitting report of commanding officer relative to	43	26
War Department, relative to contingent expenses of	12	26
transmitting statement of contracts entered into by	39	26
transmitting list of employés of	63	26
transmitting report on useless papers in	250	29
Secret service, letter of Secretary of Treasury transmitting request for additional appropriation for	166	29
Shoshone and Arapahoe Indians, letter of Secretary of Interior relative to negotiations with	51	26
Shoshone Agency, Wyo., letter of Secretary of Treasury transmitting estimate for erection of flour mill and saw mill at	77	26

Subject.	No.	Vol.
Sioux Falls, S. Dak., referring to estimate for completion of public building at	240	29
Slums of cities, report of Commissioner of Labor on		31
Soldiers' Home, letter of Secretary of War transmitting bill to regulate admission to	38	26
South Pass. (*See* Mississippi River.)		
Southern Pacific Railroad Company, letter of Secretary of Treasury transmitting transportation claims of	168	29
Statistical Abstract for 1893	97	28
Statistical abstract of foreign countries, letter of Secretary of Treasury transmitting request of Chief of Bureau of Statistics for authority to print	198	29
Steamships, letter of Secretary of Treasury relative to bill to facilitate entry of	191	29
Stone lands. (*See* Public lands.)		
Supervisors of elections, letter of Secretary of Treasury transmitting request for appropriation to pay certain	148	29
Supreme Court, letter of Secretary of Treasury transmitting estimate of deficiency for printing and binding for	149	29
T		
Tampa Bay, Florida, letter of Secretary of Treasury relative to establishing lights	246	29
Tennessee, letter of Secretary of Interior transmitting statement of Commissioner of Education relative to attack on educational standing of	173	29
Tests of iron and steel, report on, at Watertown arsenal	43	26
Timber lands. (*See* Public lands.)		
Treasurer of United States, letter from, transmitting copies of accounts of First Comptroller	31	26
estimate for additional clerk in office of assistant at Cincinnati	226	29
letter of Secretary of Treasury submitting recommendations for increase of force for assistant treasurers at St. Louis, Chicago, and New Orleans	216	29
Treasury, letter of Secretary of Treasury relative to new machinery for bindery of	170	29
letter of Secretary of the Treasury relative to deficiency in appropriations for the contingent expenses of	197	29
letter of Secretary of Treasury transmitting estimate to pay special agents	219	29
Treasury Department, letter of Secretary of Treasury transmitting list of useless papers in	208	29
letter of Secretary of Treasury transmitting request for additional appropriation for secret service division	166	29
letter of Secretary of Treasury relative to contingent expenses of	13	26
Treasury notes, letter of Secretary of Treasury relative to 7.3 per cent notes	188	29
Tucker, Irwin, letter of Postmaster-General transmitting papers in case of claims of	178	29
U.		
Umpqua River light station, letter of Secretary transmitting estimate for finishing	131	29
Union Pacific Railway, letter of Attorney-General relative to appointment of receivers of, etc	194	29
Company, letter of Attorney-General transmitting bill, etc., to secure claim of the United States	203	29
Unproductive property. (*See* Public property.)		

Subject.	No.	Vol.
V.		
Vessels, letter of Secretary of Treasury transmitting amendment to section 5294 of Revised Statutes	251	29
Veterinarians. (*See* Army.)		
Veto, letter of President returning bill (H. R. 3289) without his approval	81	26
letter of President returning bill (H. R. 71) relating to proof by purchasers of stone and timber lands	75	26
letter of President returning bill for relief of Eugene Wells	259	29
War Department, letter of Secretary of War relative to contingent expenses of	12	26
letter of Secretary of War transmitting statement of contracts entered into by	39	26
letter of Secretary of War transmitting list of employés in	63	26
letter of Secretary of Treasury relative to rent of building for Record and Pension Division of	192	29
letter of Secretary of Treasury transmitting estimate for rent of Union Building for Record and Pension Division of	213	29
letter of Secretary of War transmitting report on useless papers in	250	29
Watervliet Arsenal, letter of Secretary of War transmitting recommendations relative to paving at	139	29
Wells, Eugene, veto by President	259	29
White, J. K., letter of Secretary of Treasury relative to claim of	53	26
Winston, Alexander M., letter of Secretary of Treasury submitting estimate to pay for services	171	29
Woodson, Daniel, statement of amount found due to	221	29
Worlds' Columbian Exposition, letter of Secretary of Treasury transmitting report of collector of customs for	165	29
Yankton Sioux Indians, letter of Secretary of Interior transmitting papers relating to ratification of treaty with	80	26
Yuen, Sam, letter of Secretary of the Treasury relative to	174	29

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53D CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FIFTY-THIRD CONGRESS.

IN FOUR VOLUMES.

VOLUME III.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.

REPORT OF THE CHIEF OF ORDNANCE.

WAR DEPARTMENT, ORDNANCE OFFICE,
Washington, October 1, 1893.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1893, with such remarks and recommendations as the interests of this branch of the military service seem to require.

The fiscal resources and expenditures of the Department during the year were as follows, viz:

Amount in the Treasury to the credit of the appropriations on June 30, 1892	$4,988,860.80
Amount in the Treasury not reported to the credit of the appropriations on June 30, 1892	817.87
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1892	532,296.47
Amount of appropriations for the service of the fiscal year ended June 30, 1893	2,832,277.89
Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1893	226,081.34
Gross amount received during the fiscal year ended June 30, 1893, from sales to officers; from rents; from collections from troops on account of losses of or damage to ordnance stores; from Chicago, Rock Island and Pacific Railroad Company; from powder and projectiles (proceeds of sales); from sales of condemned stores; from testing machine, and from all other sources not before mentioned	41,208.50
Total	8,621,542.87

Amount of expenditures during the fiscal year ended June 30, 1893, including expenses attending sales of condemned stores, exchange of powder, etc	3,702,202.66
Amount deposited in Treasury during the fiscal year ended June 30, 1893, as proceeds of sales of Government property	9,036.12
Amount turned into the surplus fund on June 30, 1893	3,644.97
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1893	553,400.05
Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1893	4,281.18
Amount in the Treasury not reported to the credit of appropriations on June 30, 1893	436.04
Amount in the Treasury to the credit of appropriations on June 30, 1893	4,348,541.85
Total	8,621,542.87

CLERICAL FORCE.

I deem it my duty to invite your attention to the evils resulting from an inadequate clerical force in this office. This has been reported in previous years, and the Secretary of War has directed that an estimate be submitted to Congress for a sufficient clerical force. This has been done, but the necessary appropriation has not been granted. An estimate for this purpose has again been included in my estimates for this year. Five additional clerks are necessary. Notwithstanding careful efforts to minimize the clerical work that must be performed, the largely increased business of the Department, due to work of gun construction for coast defense and a constant increase of office work from other causes, the necessary clerical labor is constantly increasing. There is now a large arrear of clerical labor, which the interests of the service demand should be brought up to date. With the present force this is impossible, and, on the contrary, the necessary current work of each year can not be properly performed.

Four clerks were withdrawn from this office when the Record and Pension Division of the War Department was organized. The five clerks asked for are to provide for replacing these and to give one additional clerk.

THE DISTRICT OF COLUMBIA MILITIA.

My annual estimates of this year contain an item for arming and equipping the militia of the District of Columbia. The following remarks on this subject are copied from my annual report of last year:

> The act of March 1, 1889 (vol. 25, p. 77, 2 Stat. L.), to provide for the organization of the militia of the District of Columbia, provides (section 31) that the ordnance and ordnance stores necessary to arm, equip, and instruct said militia shall be issued from the stores and supplies provided for the use of the regular Army; but the act failed to make any appropriation to enable the Ordnance Department to make good the depletion of the limited army supplies by these issues to the militia.
>
> As the property issued as provided for in this act must be taken from the supplies for the Army—that is, from the appropriations for these supplies—and as it is a fact that the appropriations now made are insufficient for the actual needs of the Army, it is evident that if the militia is supplied the Army will suffer, and *vice versa*.
>
> The issues thus far made under this act amount to $45,621.54, and an item of this amount is embraced in the estimates to be laid before Congress. In my judgment it would be wise to have a permanent appropriation of a fixed amount for each year to provide for these issues to the District militia, or a specific appropriation for each year.

The importance of maintaining the efficiency of the District militia need not be stated. The small allotment due to the District from the general appropriation for arming and equipping the militia of the United States is inadequate for this purpose.

APPROPRIATION FOR ARMING AND EQUIPPING THE MILITIA OF THE UNITED STATES.

Your attention is invited to the inadequacy of the general appropriation for arming and equipping the militia. The act of 1808 fixed the amount annually allotted for the militia of all the States at $200,000. The improved arms, equipments, artillery, and other stores of the present day cost for the same number of men more than three times the cost of the same eighty-five years ago, when the act was passed. The population of the country is now more than ten times that of 1808, and the demand for these equipments has increased more than ten times. The act of February 12, 1887, increased this appropriation, but made it include also camp and garrison equipage and clothing furnished by the Quartermaster's Department. I stated in my annual report for 1892 that this act, instead of increasing the appropriation for arming and equipping the militia (that is, the portion used for arms and equipments), as was intended by Congress, actually resulted in a reduction of this portion of the appropriation that year to $173,000. The demand since that time has largely increased, and the value of the ordnance stores issued to the militia during the fiscal year ended June 30, 1893, was $226,821.49. Notwithstanding this large increase in the issues during the past year, the demands which could not be supplied were greater than in previous years.

The above figures show how inadequate the present appropriation must be. Experience proves that it is so. The small allotment which can be made to each State from the appropriation is carefully husbanded and economically used, but is insufficient. The War Department is troubled by requests from the States for larger supplies than can be furnished under the allotments. The urgent importance of maintaining not only the present force and efficiency of the States' militia, but of enlarging the same, is admitted and urged by the War Department. It is a hardship, then, for the Department to be constantly compelled to refuse the most needful supplies. The inability to furnish these supplies not only cripples the efficiency of the militia force and dampens the valuable ardor of officers who are engaged in promoting its efficiency, but makes a further enlargement of the militia force, which is so necessary, practically impossible. It is hoped that if this matter is urged upon the attention of Congress a more suitable appropriation for the armament and equipment of the militia may be made.

In this connection I would also invite your attention to a communication sent to you on March 21, 1892, and published in my report of last year:

This communication was submitted to Congress by you, but no action was taken thereon.

Before entering into an account of the operations of my Department during the past year, I desire, in this part of the report, where it may

attract attention, to advise you of the insufficient number of officers in my Department for the performance of the necessary duties imposed upon it. The increase of technical knowledge and of highly educated and technically trained men demanded in the industrial pursuits of civil life, and the advantages resulting from supplying this demand, are well known and practiced. The advantage and imperative necessity for having specially educated and technically trained officers for the numerous duties imposed upon this Department is, generally speaking, greater than for the industrial pursuits mentioned. I think this statement will be borne out by examination and consideration of the report, further on, of the operations of the Department during the past year. For most of the duties required of the officers not only special and technical education is required, but also much subsequent study and experience is necessary to make the officer's services of value. At the present time, in my judgment, at nearly every important ordnance station, additional trained ordnance officers would give to the Government benefits far exceeding in value the cost of their maintenance. It might be admitted that ten years ago there were enough officers for the performance of the duties, but the large number of officers required on inspection work in connection with gun construction alone has totally changed the condition of affairs. Further, the increase of technical and scientific work of all kinds connected with modern armaments and equipments, and the advantages which have been referred to of having more technically trained officers employed on such work, has further increased the demand. Further, in my judgment, it is not probable that at any future time this demand will be diminished.

To illustrate the foregoing, I will state that at the present time the commanding officer of Rock Island Arsenal has only one assistant, and another officer can not be spared for that arsenal.

It has been of the highest importance for two years to have an officer selected especially with reference to his abilities, placed exclusively on duty in connection with the manufacture of powder, and who could devote all his time to the subjects connected therewith. It has not been practicable up to the present time to spare an officer for this duty.

SEACOAST GUN-CARRIAGE FACTORY AT WATERTOWN ARSENAL.

Work on the installation of a modern gun-carriage plant at this post has progressed satisfactorily during the year. New shops have been erected, old shops and storehouses have been enlarged and remodeled, and most of the large tools required for the equipment have been delivered and are either set up or are in readiness to be set up. The foundry building has been extended and this extension fitted up, as an auxiliary machine shop, with certain large planers, boring mills, slotters, etc., and a 20-ton traveling crane. This shop is connected with the foundry by a railroad track. A 20-ton traveling crane has also been put in the foundry and a new core oven erected there of sufficient

capacity for the largest carriage castings. This foundry may be now considered as completed, the additions made to it having more than doubled its capacity.

In the south wing of the principal machine shop the first and second floors have been removed, the cellar filled up to the ground level, and the largest machine tools required for heavy gun-carriage work put in place.

This wing is connected by railroad tracks with the foundry and foundry extension and the new erecting shop. The erecting shop is being built near the machine shops. It is a single story building 280 feet long by 80 feet wide and 25 feet high to the cornices. Brick piers are built in the walls for the traveling crane and a railroad track connects the building with the Fitchburg Railroad.

For the present the south end of this building only will be used as an erecting shop; the north end for the storage of carriages. The storehouse on the northwest corner of the old arsenal inclosure has been converted into a complete carpenter and pattern-makers' shop, and a house for the 80-horse power engine, with tool room and foreman's office, has been provided by building an L addition.

By the fortifications acts of February 24, 1891; July 23, 1892, and February 18, 1893, Congress has appropriated, in the aggregate, $284,050 for this plant.

Work on the manufacture and alteration of carriages has progressed during the year as favorably as could be expected, where the plant was undergoing such extensive alteration and extension.

The manufacture of cast-iron projectiles for seacoast guns has been very satisfactory, and under the limited appropriations all cast-iron projectiles will be made at this post in future.

In connection with the establishment of a gun-carriage plant at this arsenal, the question of water transportation for the shipment of carriages, most of which are too large for rail transportation, becomes of first importance. The Charles River, which borders this arsenal reservation, should, if it be practicable, without too great expense, be so improved as to furnish this much-needed means of transportation. The condition of that river has become so noisome, by reason of sewage emptied into it from towns along its banks, that a commission has been appointed by the State to consider plans for remedying the evil. I would recommend that the General Government also take part in the matter, and make the necessary surveys to ascertain what work, if any, is required to make the river navigable for the requirements of the arsenal as a point of supplies—such action to be preliminary to submitting estimates for the necessary appropriations for undertaking the work.

The testing department of this post has been fully occupied during the year making tests, both mechanical and chemical, for the acceptance of ordnance material, to be delivered under contract, and in the

interests of private parties who have submitted a great variety of materials for test. Among the latter tests may be mentioned an extensive series of automatic car-coupling tests. The material for these tests was collected and submitted by the Master Car-builders Association, whose members represent all the principal railways of the country, and who are acting in accordance with the views of the Interstate Commerce Commission in the selection and adoption of a suitable car coupling that will meet the requirements of the law.

Some very interesting investigative tests have been prosecuted during the year, looking to the determination of the physical laws that regulate the behavior of certain forms of material when subjected to stresses. These tests so far as completed will appear in the annual report of the tests of metals.

In connection with this testing work the necessity for a smaller testing machine, as an auxiliary to the large one, becomes more and more pressing every year. By means of such a machine many of the smaller specimens could be tested with considerable saving in time and labor, and leave the large machine free for the heavier and more important work required. The Department has submitted an estimate for the purchase of such smaller machine for several years, but without success. I have, however, renewed my appeal for an appropriation in the estimates for the next fiscal year.

The investigative tests of the last few years have also developed a demand for, and have demonstrated the great advantage the industrial interests of the country would derive from, a drop testing machine, and I have also included an estimate for such a machine in my annual estimate. It would be specially advantageous in some of the tests required for the Ordnance Department.

The alteration and rearrangement of buildings heretofore described has left sufficient additional space to the testing department to provide for these machines.

ARMY GUN FACTORY, WATERVLIET ARSENAL.

By the fortifications act of July 23, 1892, Congress authorized the expenditure of $346,600 to complete the equipment of the south wing of the army gun factory. Only a part of this sum was actually appropriated by the act of July 23, 1892.

In 1893, when the Department submitted an estimate for the balance, Congress postponed making the full appropriation in order to reduce expenditures as much as possible for last year. On this account, completing the equipment of the south wing could not be so vigorously pushed, and is not as far advanced at this time as I had anticipated in my last annual report.

However, the large boring and turning lathes and rifling machines, for the manufacture of guns up to 12 inches in caliber, have been delivered complete, with the exception of some of the back rests which

are now being made and set up in place. There has also been delivered a number of the smaller machines required for the manufacture of 16-inch guns.

The north wing of the gun factory now contains eight boring and turning lathes, five turning and finishing lathes, and one rifling machine, of the character above described. The south wing contains four boring and turning lathes, six turning and finishing lathes, and one rifling machine suited to the manufacture of 12-inch guns. The equipment of the south wing will be completed by three boring and turning lathes and one turning and finishing lathe, suited to the manufacture of 16-inch guns, and the rifling machine in this wing will also be adapted to guns of that caliber.

When the gun factory is fully occupied it is proposed to manufacture 8 and 10 inch guns in the north wing, and 12 and 16 inch guns in the south wing.

Proposals have been issued for an electric traveling crane, of 60 tons capacity and 60 feet span, for use in the south wing, in addition to the 120-ton crane; also for a 30-ton traveling crane of 20 feet span for the west aisle, in which are to be located the jacket lathes. Proposals have also been issued for a portable weighing scale of 300,000 pounds capacity. This scale will occupy but little space, and when not in use will be moved to one side and out of the way.

Overhead trolleys of 5 tons capacity, with differential hoists, have been put into the south wing, in the side aisles, and also into the central section, for the transportation of hoops and other material up to 5 tons weight, to avoid the constant use of the large traveling cranes in the main aisle. For the same reason narrow-gauge tracks, with shop trucks, have been provided in various localities connecting the main aisle with the side aisles.

The question of the most suitable form of back rest for the large gun lathes has been under investigation and experiment for many months. After exhaustive trial the superiority of back rests with rotating chuck rings has been fully established, and that form of rest has been adopted, and will be applied to fifteen of the gun lathes. It is believed that by the use of these rests the work of finishing the guns will be considerably shortened, and thus cheapened, and that greater accuracy will be attained. The designs for the 16-inch lathes and the 16-inch threading and slotting machines are approaching completion, and proposals will soon be issued to machine-tool builders for supplying the Department with these machines.

An oil house and locomotive shed have been built, during the past year, in a location convenient to the gun factory. A plan for the storage of coal and the handling of coal and ashes is under preparation.

From the experience thus far had in the manufacture of guns in this establishment it becomes evident, as the factory approaches completion, that the estimated output will be exceeded, even though the

mechanics are limited to eight hours' work per day. The cost of the guns has not been above the estimated cost, and it will probably become less in time.

During the year the introduction of a definite system of work has been commenced, and shop regulations for the government of employés, etc., have been introduced. Generally speaking, the work has progressed smoothly, economically, and expeditiously.

Proposals have been invited for an electric light and power plant, for which there is an available appropriation. This plant should be completed during next November, and is greatly needed, as, at present, owing to the generally leaky condition of the gas pipes, the use of gas at the post has been discontinued. This plant will be operated by available water power through turbines located in the shops east of the canal, and it is proposed to so utilize it, in connection with the gun factory, that during the day, when lights are not used, this power may run the electric cranes and supplement the engines of the gun factory, and also so that any surplus power left at night, after electric lighting, may be used in the same way. This plan further permits running the lower shops and electric plant there from the gun factory engines whenever the water power may be temporarily unavailable without the cost of maintaining a steam plant at the lower shops, and is inadequate to the present needs of the post. An appropriation for reconstructing this plant was made by Congress at its last session, but as the appropriation made was below the estimate submitted a further appropriation to complete the plant has been submitted in my estimates for the coming year.

The plan now proposed is to remove the old and locate four improved modern turbines, each of thirty-horse power capacity, on the site of the present two water wheels in the lower machine shop. This arrangement should be adequate and furnish great conveniences, as well as reduce expenses.

Under an appropriation contained in the sundry civil act of July 3, 1892, that part of Broadway situated between the western rail of the electric railroad and the curb was paved last year with granite blocks over the whole extent of the arsenal frontage. An additional appropriation made by the sundry civil act of February 18, 1893, will permit of paving the eastern side of Broadway, and this work will be taken immediately in hand. Considerable work on the paving of roads and walks and improvement of the grounds inside of the arsenal inclosure still remains to be done, and an estimate for this purpose has been submitted in my annual estimates to Congress.

The present water supply of the post is insufficient and unsatisfactory as respects both manufacturing and domestic purposes, and to procure a proper supply of good and suitable water for the needs of the post an item of $11,858 has been embodied in my annual estimates for next year.

These various topics are treated at length in Appendix 21 to this report.

SANDY HOOK PROVING GROUND.

The number and variety of firings conducted during the past year for experimental and proof purposes have been greater than during any previous year in the history of the proving ground.

This, as a matter of course, has largely increased the current labor at that post. To meet this increase of work improved facilities for handling heavy ordnance have been provided in a Gantry crane; new arrangements have been made of the proof butts, by which much time and labor are saved in overhauling the butts, and the capacity of the machine shop has been enlarged by the addition of a new engine and boiler and woodworking machinery. To facilitate the shipment of heavy guns, etc., the wharf has been repaired and greatly strengthened, so that it will now bear guns of 12-inches caliber.

During the year about 6 miles of railroad tracks, including sidings with frogs and switches, situated on the reservation, have been purchased from the Central Railroad Company of New Jersey, and are now available for Government use. To utilize these facilities to the fullest extent it only remains to connect this railroad with the Gantry crane at the main firing battery by a branch road passing up along the beach. The building of this road is already under way, and, when completed, guns and carriages can be delivered at the firing battery on cars direct from the place of manufacture, at a great saving of labor and cost of transportation.

By the fortifications act of February 18, 1893, the sum of $3,500 was appropriated for the purchase of a locomotive engine for the use of this post.

ROCK ISLAND ARSENAL.

Owing to the deterioration of the bridges connecting the city of Rock Island with the island, and the latter with Davenport, extensive repairs were required. The weight of the engines and cars of the Rock Island Railroad has been greatly increased since the bridge was first built, and this requires increased strength in the main bridge. On the bridge to Rock Island the iron floor beams were replaced by steel beams of heavier section, while on the bridge to Davenport the wooden floor beams originally laid were replaced by steel beams. These repairs were completed during the fiscal year ending June 30, 1893.

The following is an abstract of the travel over the bridge to Davenport during the year:

	North.	South.
Engines with train	11,278	11,307
Engines without train	513	499
Total engines	11,791	11,806
Passenger cars	19,367	19,330
Freight cars	137,088	135,732
Foot passengers	239,352	242,979
Teams	197,068	195,643

PASSAGE THROUGH DRAW.

	Up river.	Down river.
Steamboats	1,410	1,490
Barges	449	407
Rafts	.....	741

A small bridge over the tail-race canal has been recently repaired.

The railroad in the arsenal grounds has been extended to a point west of Storehouse K, thus making this storehouse and the adjoining part of the "armory row" of shops more convenient for rail shipments.

Storehouse K is now completed and in use.

The 13-ton steam hammer, transferred from the Springfield Armory for the manufacture of 3.2-inch gun carriages, has been set up in the smith shop and provided with the necessary heating furnaces.

The necessary work required for placing old and new machinery in other shops has been progressing rapidly with a view to preparing for the additional output required of this arsenal.

SPRINGFIELD ARMORY.

The building for the new machine and filing shops, of which the interior has been finished during the year, completes the group of new fireproof buildings for the finishing shops of the armory in Federal Square. The group comprises also the new milling shop and new building for carpenter and stocking shops, which together form three sides of an open court or square. The building for machine and filing shops, 458 feet in length, occupies the north side of the court and connects the other two, which are parallel and opposite to each other, each of which is 279 feet in length. The three buildings are alike in general plan, built principally of brick and iron, and having two floors, basement, and attic. Details of the work are given in the report of principal operations at the armory for the past year, published herewith.

The new steam-power plant has been placed in the central building during the year. It comprises a pair of Corliss compound condensing engines of 150 horse-power each, and four Babcock and Wilcox boilers, with feed-water heater and two steam pumps, furnished and erected

by the Philadelphia Engineering Works. This work should have been completed in May last, but the tests of the engines developed points requiring correction which have delayed the final acceptance of the plant.

The milling shop, as previously reported, has been operated by power transmitted through shafting run under Federal street from the existing power plant. The fitting up and placing of machinery in the stocking and carpenter shops is in progress, and the shops will be ready for operation upon the completion of the new power plant. The erection of the main lines of shafting in the machine and filing shops was completed in January. By June 30 such progress had been made in the arrangement of machinery in these shops for work on the new magazine rifle as to anticipate readiness for that work in October.

The preparations for the manufacture of the new arm were begun at the armory in September, 1892. Such a change of manufacture in an establishment of the magnitude of the Springfield Armory always involves an immense amount of detail and study in developing the best methods of making each component piece of the arm, of performing the operations upon each piece, of arranging the tools and fixtures for these operations, and, finally, in preparing the large number of gauges needed to verify the correctness of the work and secure interchangeability of parts. The total number of parts in the .45-caliber Springfield rod-bayonet rifle is eighty-four, and in the manufacture of that arm, omitting the stock, there were employed 449 "fixtures" and 1,097 "gauges." The new magazine rifle has eighty-eight parts, or four more than the .45 caliber Springfield single loader.

The manufacture of the .45 caliber rifle was brought to a close during the month of June, with the termination of the fiscal year. The forging of parts of that arm was stopped in February, and afterwards only such pieces were forged or completed as were needed for the arms to be completed within the year or for repair of arms in service. Workmen were laid off from day to day as their services were no longer needed, and these steps were taken with the very necessary purpose of reducing to a minimum the amount of surplus components of the arm to be left on hand. Twenty thousand seven hundred and sixty-one .45 caliber Springfield rod-bayonet rifles, model 1888, and Springfield cadet rifles, model 1884, have been manufactured during the year; also a few .30 caliber experimental Springfield single-loading rifles, having the same interior dimensions of barrel as the new magazine rifle, to be used for test of ammunition for the new rifle pending the completion of samples of that arm.

The plans and specifications for two sets of officers' quarters at the armory, for which $20,000 was appropriated by the army act of February 24, 1891, are published herewith as a guide for like constructions which may be required from time to time. The specifications are those originally drawn for advertisement and with a view of building

under contract; but advertisement having been issued at two separate times and no satisfactory bid received, within the limits of the appropriations the building operations now in progress are performed by day labor and with materials procured directly by the Government.

FRANKFORD ARSENAL.

The development of our modern war material has added so much to the importance of the work at this arsenal and to the demands upon its resources that the occupancy of more shoproom than the buildings now in use for this purpose contain or afford, is rendered obligatory. A new building is not required, since one built originally for a rolling mill, but not equipped with machinery, is available and well suited for the purpose. The various operations in the manufacture of small-arm cartridges are at present, of necessity, conducted in four different detached buildings, not suited by reason of location and size for the most economical work on even the present output of cartridges. These buildings are, besides, overcrowded with recent additions of plant required for the manufacture of new model gun sights, fuses, and cartridge cases of large size, or fixed ammunition for mountain and field artillery. With the transfer of the principal plant to the now empty building, space will be afforded under one roof for convenient arrangement of all the successive operations, and facilities given for an expansion from the present maximum output of 36,000 cartridges per day to 250,000 to meet an emergency. There is urgent need for the appropriations required to carry out this rearrangement of the plant, and for machinery for the manufacture of artillery ammunition, which are included in estimates submitted for arsenals under the sundry civil bill.

Besides the regular output of .45 caliber ammunition for arms in service and manufacture of sights for field and seacoast cannon, gunners' quadrants, cannon primers and fuses of various descriptions, star gauges and other inspecting instruments for cannon and projectiles, etc., special attention has been given during the year to the perfecting of the small caliber ammunition for the new magazine rifle and of the .38 caliber revolver recently adopted for service. A quantity of the revolver ammunition was made and issued to troops armed with the new revolver. The limited plants for the manufacture of the Frankford Arsenal combination fuse and shrapnel, established a year ago, have been kept in operation. Substantial progress has also been made in preparing the limited plant proposed for drawn cartridge cases and fixed ammunition for mountain and field artillery; its completion is, however, prevented by lack of funds, and the output, so far, is limited to the making of a small quantity of fixed ammunition for mountain guns and sample cartridge cases and shrapnel for fixed ammunition of the 3.2-inch field gun for trial.

All the testing and examination of smokeless powders for small-arms for the military service, except to a limited extent at Benicia Arsenal,

California, has been concentrated at the Frankford Arsenal, and the year has been marked by special activity in this work.

Chemical laboratory.—The chemical laboratory at Frankford Arsenal, of which mention was made in previous reports, has been completed and put to use. A report of its equipment and operations by the officer in charge is appended. Samples of a number of explosives and powders have been received, and have been examined, or are undergoing examination. The laboratory is equipped for the work of examining samples of explosives, smokeless and other powders, as regards their composition and chemical and physical properties, the results of which, taken in connection with the ballistic tests, may serve as a guide to manufacture and in determining the suitability of the product for military use. Laboratory tests may not, however, be considered conclusive as to the keeping qualities of a powder, for despite the artificial conditions of exposure which may be there carried out, experience has shown that subjecting the powder or ammunition for a length of time to the trying climatic conditions of service is required as a final test.

BENICIA ARSENAL.

Additions have been made to the plant of this arsenal during the year to facilitate the test of powders manufactured for the Department on the Pacific coast and to enable experiments to be made, particularly with samples of smokeless powders for small arms and cannon, which inventors in that vicinity may desire to have tested by the Government. A house for ballistic instruments has been built and furnished with the necessary instruments for measuring velocities and pressures, and a bombproof has been erected on the proving ground. The outfit of the instrument house includes a Boulengé chronograph with Bréger attachments of latest pattern and .30 caliber rifle and pressure barrel adapted to test powders and projectiles suitable for the new .30 caliber magazine rifle. An officer of the Department, at the arsenal, has been charged with the duty of carrying out experiments and corresponding with manufacturers of such products, with a view to keeping the Department informed of the progress made, and with a view also to informing experimenters of the intention of the Department to aid in development of suitable smokeless powders for guns and of explosives for projectiles.

For economic reasons, to increase the productive capacity of the Department in times of emergency, and especially to provide for necessary work on the Pacific coast in times of emergency, it is very desirable that the shops at this arsenal should be put in condition and other provision made for repairs of stores and certain limited manufactures at this arsenal.

GATLING MACHINE GUNS, .30 CALIBER.

Pursuant to advertisement for caliber .30 machine guns issued by the Department in May last, a contract has been made with the Gatling Gun Company to furnish eighteen guns of this caliber, to be delivered in December. These guns, except the caliber and also a new form of "feed," are the same as the Gatling guns purchased during the past three years and known as the long-barreled gun, with ten barrels. Each gun will be supplied with the hopper design for the "new positive feed," and will also be adapted to use the Bruce (gravity) feed with two guides and hopper complete, so that either of these forms of feed can be used by a change of hopper. The guns will also have the improvements designed and made at the Springfield Armory, for throwing off the locks for practice and drill, and an elevating lever, besides the customary spare parts and implements, together with two hundred of the tin feed strips which are used with the new feed for each gun. The United States will have the right to manufacture these strips hereafter in any quantity without payment of royalty.

A sample gun of this description has been tried by the Department to test the mechanism at the Springfield Armory, in June, with satisfactory results as to the working of the mechanism of the gun and of the new feed to the limited extent in which it was then tried. A description, with drawings, of this feed, prepared by the Gatling Gun Company, is published herewith (Appendix 42). It is claimed for this feed that it is positive, simple, and accurate in its action at all angles of elevation or depression and gives a high rate of speed in the delivery ot fire by hand, whilst the rapidity by power (electric motor) would seem to have no limit but the endurance of the parts, and that it enables the cartridges to be fed direct to the gun as packed in the feed strips at the factory without any intermediate handling. The form and dimensions of the cartridge-holding strips are such as to permit of close packing for transportation and economy of space in the field ammunition chests as proposed to be carried ready for use with the gun.

MAGAZINE RIFLE, MODEL 1892, CALIBER .30.

Preparations for the manufacture of this arm at the Springfield Armory, Massachusetts, and of the ammunition at the Frankford Arsenal, Pennsylvania, have been concurrently carried on with all possible dispatch since September last, when the magazine system of the arm was approved for trial with a view to adoption in the military service pursuant to the recommendations of the Board on Magazine Arms in 1892, as stated in my last annual report. The magnitude of the work attending these preparations, of which details are given in Appendix 11, has already been referred to in my remarks upon the Springfield Armory. At this date the preparations are practically complete. A certain number of the arms will be completed at the armory during the current fiscal year, and although a smokeless powder for the

ammunition has not yet been adopted for service, a sufficient quantity of the Wetteren powder has been ordered to furnish what is required for immediate needs, pending the now very encouraging outlook for securing a suitable powder of domestic production. Excepting the powder, the arrangements for manufacturing the ammunition in quantity are now complete.

Aside from the "magazine system," which is the Krag–Jorgensen, modified in important details to meet objections found by the board to the original and other models of the same system presented for trial, the details of caliber, rifling, and ammunition of the arm as now to be made have been determined by a series of experiments instituted and actively prosecuted during several preceding years by the Ordnance Department.

The report of the board of ordnance officers, mentioned in the last annual report, convened to recommend a suitable caliber, rifling, sights, and ammunition, besides the bayonet, ramrod, and other appendages required for issue with the rifle and carbine, has been since received, and is published as Appendix 10, herewith. All the recommendations of this board have been approved and action taken in accordance therewith.

The caliber of 0.30 of an inch (7.62 mm.) adopted for the rifle is one well suited to a military arm, and especially adapted to the breech and magazine mechanism of the system selected for trial in service, as had already been determined by the experiments and tests. To have attempted to change at this time the caliber of the arm would have necessitated a long delay for further experiment, which was impracticable in view of the recognized deficiency of our existing service rifle with respect to other nations, and the necessity for the speedy introduction of a modern type of small caliber magazine arm. The caliber .30 is the same as that of the Russian arm, and intermediate between the arms of Austria, Belgium, England, France, and Germany, which are larger, ranging from 0.301 to 0.315 of an inch, and those of Holland, Italy, Spain, Roumania, and Switzerland, which are smaller, ranging from 0.256 to 0.295 of an inch. At the present time there is a tendency of professional opinion to the use of a smaller caliber than .30. The gain at most can be but slight. The necessary experiments to guide the Department for future action in this regard will be made.

The sights of the rifle are designed more for use in war than for the special use of the target ground, as it is wise to provide a sight which will be used by the soldier at all times in the same manner as in battle, though a certain number of rifles may be provided with telescopic sights for special organizations. It is simple in construction and manipulation, and strong and durable.

The bayonet is of the knife pattern, with metal scabbard. The specifications of the board for the ammunition require a weight of bullet 220 grains and a charge of 36 to 40 grains of smokeless powder, or such

lesser weight as will give a muzzle velocity of about 2,000 feet per second, with a chamber pressure not exceeding 45,000 pounds per square inch. These conditions it is found in practice, however, can be considerably ameliorated, and a higher velocity obtained with considerably less pressure from several of the samples of smokeless powder that have been tested. This ammunition will not be reloaded by troops.

The carbine of this system will be of the same caliber as the rifle, and adapted to the same cartridge, the barrel being shortened from 30 to 22 inches, and the sights of the same general design as those for the rifle.

Steel for rifle barrels.—Difficulty has been encountered in procuring a suitable steel for these rifle barrels. Prior to the middle of August (1893) some thirty-eight samples of steel for .30-caliber rifle barrels were received at the Springfield Armory for trial from manufacturers. The requirement for elastic limit of test specimens was in September, 1892, placed at 80,000 pounds per square inch to encourage experiments with nickel steel, but as it subsequently appeared impracticable to obtain a steel with that limit of elasticity that could be worked, the standard was reduced to require an elastic limit of not less than 60,000 pounds, with tenacity about 100,000 pounds, and elongation 15 to 20 per cent, the metal to be homogeneous, free from seams and hard spots, and to be capable of being readily worked by tools. In a number of the samples the physical properties approached the standard requirements, but when the most favorable ones were tested in making barrels hard spots or seams were found, which arrested or diverted the drill and produced a crooked bore. A number of barrels have been made from these samples, of which four, manufactured from steels giving under the specimen tests the elastic limits (1) 45,000, (2) 56,000, (3) 79,000, and (4) 86,000 pounds per square inch, respectively, have been tested by firing 1,010 rounds from each with a charge of 36 grains of Wetteren powder and the experimental bullet weighing 230-grains. The steel in barrels 2 and 4 contained nickel, the former a per cent not stated and the latter 3 per cent. The results of the firing were practically the same in all the four barrels, showing an ultimate loss of velocity of from 80 to 90 f. s., nearly all of which occurred before the six hundredth round. Better results than these have, however, been obtained at the Frankford Arsenal with barrels furnished from the Springfield Armory and fired over 2,000 rounds, using for the first 1,000 rounds the 230-grain experimental bullet; for the second 1,000 rounds, the bullet of standard weight, 220 grains, with german-silver jacket.

TESTS OF MAGAZINE ARMS.

As a result of the announced intention of the Department, in November, 1890, to convene a board of officers to recommend a suitable magazine system for the military service, wherein all inventors were invited to compete by presenting arms for trial, a newly awakened

interest in inventions of magazine arms was engendered in the country. The board was dissolved after sessions continuing through a period of eighteen months, during which time it had examined fifty magazine arms presented by American and foreign inventors, many of the guns being the adopted arms of the principal military powers of Europe. The result of the board's labor was the selection of the system to which reference has been made.

In recognition of the continued interest exhibited by American inventors, and in the hope, based upon their recognized ascendency in past inventions of small arms especially, that further effort on their part would result in securing to the Government an improvement upon the arm already selected, all means at command were adopted to facilitate this object. To this end regulations were prepared and issued soon after final action on the report of the small-arms board, to provide for an expert examination and test of all improvements in magazine arms which might be presented. The instructions to the commanding officer of the Springfield Armory for carrying out these regulations, and the circular letter which was printed and distributed for the information of inventors, are published herewith (Appendix 11), in connection with the report of that officer of the results of examinations made in a few cases of completed arms, but chiefly of plans and drawings only. These regulations are still in force. The number of cases presented and their importance would undoubtedly have been much increased had not a new board on magazine arms been convened in March last, pursuant to act of Congress, as follows:

The act of Congress approved February 27, 1893, "making appropriations for the support of the Army for the fiscal year ending June 30, 1894, and for other purposes," provides "For manufacture of arms at the national armories, four hundred thousand dollars: *Provided*, That no part of this appropriation shall be expended for the manufacture of magazine rifles of foreign invention until such magazine rifles of American invention as may be presented for test to the War Department within the next thirty days shall have been tested by a board of officers to be selected by the Secretary of War, which board shall report to the Board of Ordnance and Fortification on or before July first, eighteen hundred and ninety-three. If the decision of said board of officers shall be in favor of any American invention and shall also receive the approval of the Board of Ordnance and Fortification and the Secretary of War, then this appropriation, or such part thereof as the Secretary may direct, shall be expended in the manufacture of such American arm: *Provided further*, That if no such American invention shall be recommended by said board or receive the approval of the Secretary of War this appropriation shall be applicable to the manufacture of the magazine arm recommended for trial by the board recently in session and approved by the Secretary of War."

This board was convened by General Orders No. 16, Headquarters of the Army, Adjutant-General's Office, March 1, 1893, for the purpose of testing and reporting upon magazine rifles of American invention presented, as provided by the law, within a period of thirty days. Afterward, by the instructions of April 7, 1893, the board was directed to receive and examine arms presented within an additional

period of thirty days, or before May 1, 1893, and to test and report upon any of the arms then presented which upon examination should be found to have sufficient merit to warrant the expense of a trial. The full report of the board is contained in Appendix 9. Fourteen arms, embracing the following systems, were submitted to the board, viz, Spencer-Lee, Lee (model 1893), Savage, Durst, Blake, Russell-Livermore, White, Hampden, and Blake No. 2. After giving a compendium of principal conditions to which, in the opinion of the board, a magazine arm of small caliber best adapted to the needs of the United States military service should conform, the report continues: "Bearing in mind these requisites, and also the manner in which the guns tested performed under trial, the board reports as follows of the different systems:" Each of the systems is then separately considered under this heading and their defects enumerated, with the conclusion in each case that the system is not suited to the military service.

The action of the Board of Ordnance and Fortification in reviewing these proceedings was as follows:

> The board considered the report of the above-mentioned board, dated May 16, 1893, and finds that no American invention has been recommended by it, and therefore forwards the report to the honorable the Secretary of War without further action, in accordance with the terms of the act, which only call for a recommendation from the Board of Ordnance and Fortification in case "the decision of said board of officers shall be in favor of any American invention."

COLT'S DOUBLE-ACTION REVOLVER, MODEL 1892, CALIBER .38.

On the 1st of November all troops of cavalry, excepting those composed of Indian scouts, will have been provided with this arm. One battery of artillery has also been supplied with them. The ammunition for it has been manufactured at the Frankford Arsenal. The description and rules for the management of the revolver and description of its ammunition are given in Appendix 13. No tools have been issued for the reloading of ammunition by troops for this revolver. It is probable that reloading ammunition with smokeless powders by troops at posts will not be practicable.

SMALL-CALIBER RIFLE AMMUNITION.

The development of the .30-caliber rifle ammunition and investigations of important matters arising in connection therewith form the subject of several interesting reports from Frankford Arsenal, which are appended.

In July, 1892, arrangements were made with the Army Medical Department to test the effect of the .30-caliber bullet upon animal tissue and bone. These experiments were conducted by Assistant Surgeon La Garde, with whom was associated an ordnance officer, at Frankford Arsenal, for the purpose of arranging the ballistic conditions of the firings and of preparing a report thereon, including the effects on the bullet, etc., to be of value to the Ordnance Department. The report of

this officer (Lieut. Benét), who assisted Dr. La Garde, is contained in Appendix 19. It was made the object of the experiments to compare the effect of bullets of large and of small caliber upon the same parts of the human body at various ranges up to and including 2,000 yards. The arms used were the .45-caliber Springfield rifle and the experimental .30-caliber Springfield rifle, using the ammunition of and having the same ballistic qualities as the magazine rifle, model 1892. The objects to be fired at were placed at short range, and reduced charges were determined for the rifle to obtain the striking velocity of bullet incident to actual ranges simulated. As regards the nature of wounds produced, it is concluded that their severity is much less with the smaller caliber, and that the severity at short ranges, with the small caliber will be further lessened by using a bullet which will be seldom or never deformed at the highest striking velocities against the hardest human bones. Incidents are quoted to show the possible slight effect of wounds produced in men by a .30-caliber bullet, and it is remarked that experiments have recently been tried in Germany and Roumania with small-caliber bullets having the jacket covering removed at the head so as to expose the lead, the object being to make the bullet mushroom on striking, thus increasing its frontage and giving more shock. It may be assumed that a bullet of this nature will not be deliberately adopted for warfare; and, moreover, a bullet which will not be deformed is preferable on account of its penetrative power and ability to wound several instead of one man. It is significant that experiments with a deformable bullet are taken up at this time in common with the tendency to reduce the caliber of rifles to 0.25 inch and even lower.

The question of the wound produced, and whether it will compel a man, when fairly struck, to leave the line of battle must have an important influence in deciding upon the minimum limit of caliber and reduced weight of bullet adapted to warfare. It being best to use a bullet that will not be readily deformed, a caliber and weight of bullet sufficient to produce serious shock in penetrating the body should be maintained. The smallest caliber that has been actually used in warfare is about 8 mm. (0.315 inch), with bullet weighing about 235 grains. Our present adopted caliber is 0.30 inch, and bullet 220 grains.

The caliber of the new army revolver is .38.

Weight of powder (black powder)	grains..	15.4
Weight of bullet	do....	150.0

(See pages 31 and 32 of my last annual report.)

The requirements for caliber for the rifle and revolver are very different. With the rifle wounds would be given at long ranges, and it is only necessary that the wound should give sufficient shock or injury to prevent the wounded soldier from holding out long enough to reach the point of attack. With the revolver the case is different. The wounds would generally be given at distances of from 10 to 50 yards,

and however serious the soldier might in some cases reach the point of attack, unless there is a sufficient shock imparted by the bullet to stop him. On the other hand, it is especially necessary in the case of the cavalry soldier that both the revolver and the ammunition should have the least possible weights. A considerable number of experiments were made, and the caliber .38 was finally adopted. Prior to these experiments, I think it was generally believed, or taken for granted, that the caliber of the revolver should be the same as that of the new rifle, and the adoption of the larger caliber received some criticism. I believe now, however, some officers in our service think the caliber too small.

The changes made in the components of the experimental .30-caliber cartridge to adapt it to the magazine rifle, model 1892, consist in a reduction of the weight of the bullet from 230 to 220 grains, and of its diameter from 0.309 to 0.308 of an inch, and the substitution of german silver for the copper covering (jacket) of the bullet, which is made without cannelures and is not lubricated. The exterior dimensions of the cartridge remaining the same, there is a consequent increase in the powder space due to the shortening of the bullet. The bullet (within the cover) is made of an alloy of 12.5 per cent tin and 87.5 per cent lead. The german-silver jacket may be regarded as tentative since experiments with a cupro-nickeled steel jacket have shown superior results as regards penetration and resistance to deformation. Fired into oak, against the grain at a distance of 3 feet, penetrations were found as follows:

230 grains, copper jacket, 4 inches, bullet badly deformed.
220 grains, german silver, 5.3 inches, bullet badly deformed.
220 grains, nickeled steel, 19.5 inches, bullet not deformed.

Compared with this, the uncovered .45-caliber bullet of the Springfield rifle gave a penetration of 3.2 inches at a distance of 50 feet; bullet badly deformed.

Fired into dry, well-seasoned oak, at a distance of 3 feet, the .30-caliber 220-grain bullet with cupro-nickeled steel jacket gave a penetration of 24.2 inches; bullet not deformed.

In the firings upon cadavers, .30-caliber bullets with the german-silver jacket were used, and explosive effects, when bones were struck, generally accompanied by more or less deformation of the bullet, were observed up to a range of 350 yards. It is inferred that with the cupro-nickeled steel jacket, which in the experiments for penetration in oak is shown to render the bullet comparatively undeformable, the occurrence of explosive effects would be less frequent, and possibly the extent of the range within which these effects occur very much reduced.

In comparative tests of lubricated and nonlubricated bullets, in the former of which the lubricant was applied in cannelures on the bullet covered by the neck of the cartridge case, whilst the non-lubricated bullets were not cannelured, two new experimental .30-caliber Spring-

field rifles were employed. One rifle was used exclusively with the lubricated and the other with the nonlubricated ammunition. Two thousand rounds have been fired from each rifle, alternating in series of fifty shots for velocity and accuracy respectively. The firings were made with a charge of 37 grains of sieved Wetteren smokeless powder and bullet with german-silver jacket weighing for first one thousand rounds 230 grains, and for second one thousand rounds 220 grains. During the first one thousand rounds there was no appreciable loss of velocity, and, as far as could be detected by gauging, no appreciable wear or enlargement of bore in either rifle. In the second one thousand rounds, with bullet of standard weight, the uniformity of velocity with the nonlubricated ammunition in every series of fifty shots was superior to that of the lubricated, but showed some falling off towards the end of the firings; and in the final gauging of the guns the rifle used with the nonlubricated ammunition showed a slight increase in diameter between the lands throughout the bore, not exceeding one and one-half thousandths of an inch. The rifle used with the lubricated ammunition showed a similar increase of diameter in some places, whilst toward the seat of the bullet there was a deposition of metal, which caused a reduction of diameter amounting in some measurements to as much as one one-hundredth of an inch, and could not be removed by ordinary methods of cleaning, but was scraped off with a wire after some difficulty. As regards accuracy, with the standard weight of bullet, the results favor the nonlubricated ammunition. On the whole, these tests indicate that lubricant is not reuiqred for a bullet with german-silver jacket. Similar tests of the bullet with cupro-nickeled steel jacket will be made.

With some of the smokeless powders tested, the primer of the cartridge, which had been made to work satisfactorily with Wetteren powder, was found to be wanting in strength and frequent miss-fires and hang-fires occurred. Experiments made to correct this defect have included several varieties of primer composition and changes in the form of the primer anvil and vent. It was found necessary in order to get sufficient strength of primer to increase the weight of the explosive pellet. Several different compositions of 0.40-grain pellet with improved anvil and reduced vent have been found to explode successfully the Troisdorf powder, which is the most difficult powder to explode that has been tried. The pressure or velocity developed in firings, where no hang-fires occurred, appeared to be unaffected either by the increase of weight of pellet from 0.25 to 0.40 grain, or by the use of pellets of different composition.

The trajectories of several rifles have been measured for a range of 500 yards by means of permanent arrangements made for the purpose at Frankford Arsenal during the year. The rifle is placed in a fixed rest with the muzzle end on a level with a bull's eye on the target and 500 yards from it. At intervals of 100 feet on the line frames are con-

structed which carry screens to be pierced by the bullet, and arranged to be raised or lowered by a cord passing over pulleys. The line of level and the vertical plane of sight are indicated by a bench mark at each screen. When the rifle has been fired the vertical height of bullet hole above the line of level is measured at each screen to give the ordinate of the trajectory at that distance. The height of the trajectory above a straight line connecting the muzzle of the rifle with the bullet mark on the target is thus obtained at intervals of 100 feet. By these means, the range being 500 yards, it is found that the greatest height of trajectory of the .30-caliber rifle is 3.85 feet (this point of the trajectory is 300 yards from the muzzle). The same greatest height is for the .45-caliber Springfield rifle 8.16 feet, and for a .40-caliber Remington-Hepburn rifle 7.7 feet. These results show the flatness of trajectory and consequently increased danger space of the .30-caliber rifle in comparison with the others.

SMOKELESS POWDERS FOR SMALL ARMS.

The examination and test, ballistic and laboratory, of smokeless powders for small arms at the Frankford Arsenal during the year have included the following:

Domestic.—Peyton, Leonard (several varieties), Dupont, Axtell, and Alters.

Foreign.—Wetteren, 1891 (Belgium), Troisdorf (Germany), B. N. F. (France), Swiss (Switzerland), and several varieties submitted by the Smokeless Powder Company, limited, London, England, including Rifleite for .30-caliber rifle, S. R. for .45-caliber rifle, and S. V. for 45-caliber revolver.

Of the domestic powders, samples of the Leonard, now controlled by the Leonard Smokeless Powder Company, New York, and of the Peyton, furnished by the California Powder Works, have given results superior to any of the powders tested. A comparison of the two is hardly warranted by the tests which have been so far reported, but it is indicated that the Peyton gives a somewhat lower pressure for the same velocity, and is the least affected by moisture and heat, whilst the Leonard, with a very moderate pressure as compared with the foreign powders, gives the more uniform results in velocity. It is gratifying to be able to state that the proprietors of both of these powders are encouraged to proceed to manufacture in quantity, and have placed samples of considerable amount at the disposal of the Department for more complete test. The Department procures all of its supply of powders from private makers, and, with the purpose of aiding in every practicable way in the development of a suitable smokeless powder of domestic production for the military service, has assisted these and other inventors by the sale of pressure barrels or rifles and parts of ammunition of standard pattern with which to make their own private tests,

whilst the samples of powder submitted have been tested by the Department without expense to the makers and the results promptly communicated for their information.

The Wetteren powder used is of a lot procured from the makers, Cooppal & Co., Belgium, about two years since, for the test of guns by the Board on Magazine Arms, and has since been continued in use for tests of ammunition, etc., by the Department, and also as a standard of comparison in tests of other smokeless powders. This lot has now been expended. In negotiating for a further supply of this powder for immediate use, pending the selection of a standard service powder, the Department has been informed of a change in the ingredients, made since the first lot was procured. Nitroglycerine is no longer used as an ingredient, for the reason, as stated, that its use results in corroding the guns.

A lot of 500 pounds of the new Wetteren powder has been procured, but as yet no tests of it have been made.

The Troisdorf powder is made by the Rhenish-Westphalian Powder Works, Germany. One lot (110 pounds) of this powder has been procured. This powder gives lower pressures in our .30-caliber rifle than the Wetteren, and seems equal to it in other respects. It requires a stronger primer for ignition, and this difficulty has curtailed its general use at Frankford Arsenal, but on the other hand has been exceedingly useful in experiments upon primers suited for the proper ignition of different kinds of smokeless powders.

But one sample of each of the B. N. F. and Du Pont powders have been tested. These and the Rifleite powder are inferior to those already named, as they give higher pressures without compensating advantages. The Axtell and Alters powders gave unsatisfactory results. No tests of the Swiss powder have been reported.

The tables which follow give representative results from the firing tests of the better grades of powder in the .30-caliber rifle under ordinary conditions, and after exposure to moisture and heat. The arrangement of the first table shows the progressive increase of pressures for the different powders, with velocities not greatly differing from the standard requirement of 2,000 f. s. muzzle velocity. About 40 f. s. must be added to each of the tabulated velocities, which are taken at 53 feet from the muzzle, to give the corresponding muzzle velocity. The difference in weights of powder charge are also noticeable. The usual moisture test, preliminary to firings, consisted in an exposure of the powder upon a screen placed over water in a closed receptacle for twenty-four hours. In the heat test the powder was exposed to dry heat at 120° F. for the same period. The experiments have been too limited to place much confidence in the results of these tests as given in the second table.

Tests of smokeless powders, .30-caliber rifle.

Powder.		Bullet weight.	Rounds fired.	Velocity.		Pressure per square inch.
Kind.	Weight.			Mean at 53 feet from muzzle.	Mean variation.	
	Grains.	*Grains.*	*No.*	*Ft. sec.*	*Ft. sec.*	*Pounds.*
Leonard, N	32	220	4	1,991	22.0	(*)
Do	33	220	5	2,037	10.2	32,500
Peyton	37	220	6	2,013	18.5	31,500
Leonard, J	31	220	6	2,019	13.8	33,500
Troisdorf	35	220	7	1,953	12.6	34,000
Do	36	220	10	2,047	16.0	40,000
Wetteren	37	220	9	1,962	19.6	38,500
B. N. F	34	220	12	1,932	10.5	47,000
Du Pont	35	220	5	1,964	9.0	54,000
Peyton	36	230	12	1,949	16.0	34,000
Wetteren	37	230	9	1,967	10.7	42,000
Rifleite	39	230	9	1,969	21.6	45,500

* Less than 32,000 pounds.

As affected by moisture and dryness.

Powder.	Exposed to moisture.			Exposed to heat.		
	Increase in weight.	Loss in velocity.	Pressure per square inch reduced.	Loss in weight.	Gain in velocity.	Pressure per square inch increased.
	Per cent.	*Ft. sec.*	*Pounds.*	*Per cent.*	*Ft. sec.*	*Pounds.*
Peyton	.238	48	normal.	.64	2	3,500
Leonard, J	2.97	100	5,000	.246	normal.	5,000
Leonard, N	3.18	100	5,000	1.690	50	6,000
Troisdorf	1.64	110	6,500	1.290	50	10,000
Wetteren	2.01	230	.....	1.500	64	.....

With the improved facilities now provided a uniform and more complete system of tests will be pursued with all promising powders. These tests will embrace determinations of velocities and pressures, using various charges; effect on velocity and pressure of exposing the powder and made up of cartridges to moisture, extreme high and low temperature and abrupt alternations from high to low temperatures and the reverse; effect on the powder of alternations from darkness to light, etc.; facility of loading by machinery; and also the effects of storage for a length of time under trying climatic conditions.

The S. R. powder for large-bore rifles was tested in the .45 caliber Springfield rifle and carbine. With the carbine good results were obtained. A charge of 25 grains developed no higher pressure than the service charge of 54 grains of black powder, and gave a slightly higher velocity with satisfactory degree of uniformity. With the rifle the results were materially inferior to those obtained with the service charge of black powder. It was deemed inadvisable to compress the charge in the cartridge, and owing to the bulkiness of the powder not more than 25 grains could be put into the normal powder space without compression. With this charge a velocity of 1,200 f. s. was obtained. Compressed charges were also tried.

The S. V. powder gave good results in the .45-caliber service revolver. A charge of 7.5 grains, under slight compression, gave the same instrumental velocity as the service charge of 28 grains of black powder, and compared favorably with it as regards uniformity for repeated shots. The pressures, judged by the ease of extraction of the cartridge case, did not seem to be excessive. The makers of these powders have been furnished facilities for further test, and expect to produce satisfactory varieties of smokeless powder for the .45-caliber arms in service, which, if adopted by the Government, would be manufactured in the United States. Since the .45 caliber rifle now constitutes the armament that would be supplied a volunteer force in case of immediate need, and will be otherwise in use by military organizations at least for some time to come, the advantages of reduced weight of ammunition, absence of smoke, and probably increased ballistic effects to be derived from the substitution of a suitable smokless powder for the present black powder, make it desirable that this change should be effected in the ammunition of the .45-caliber weapons, and also the .38-caliber revolver.

Effect of smokeless powders upon the recoil of small arms.—Investigations upon the action of different powders in the bore, and upon the recoil of the .30 and .45 caliber rifles, have been conducted by Lieut. Col. Farley at the Frankford Arsenal, and valuable data collected upon these subjects. In the .45-caliber rifle comparisons were made with charges of black and smokeless powders, and in the .30-caliber rifle with charges of different smokeless powders, arranged to produce nearly the standard muzzle velocity for each rifle. The curves of velocity and pressure in the bore were arrived at by firings made with successively shortened lengths of barrel; and the recoil, with full length of barrel was measured by a coil-spring dynamometer against which the butt of the rifle rested on firing. Approximately, it was found that the point of maximum pressure is about two calibers in advance of the base of bullet seat in the .45-caliber rifle and about three calibers in the .30-caliber rifle. The pressures rise to a higher maximum in the .30-caliber rifle, but fall off less rapidly and are better sustained to the muzzle than in the .45-caliber.

The comparison of the smokeless (30 grains S. R.) and the black (66 grains) powders in the .45-caliber rifle was rendered less satisfactory, because, as previously mentioned, the S. R. powder was not well adapted to the conditions of loading. Used, as it was, in compressed charges to obtain a muzzle velocity of 1,300 f. s. to approximate the service velocity of this arm, its curves of velocity and pressure showed no superiority over those derived from the charge of black powder. The respective recoils, measured by the dynamometer, were 10.75 foot-pounds with the black, and 9.45 foot-pounds with the smokeless-powder charge, the weight of bullet, 500 grains, being the same in both instances. The diminished recoil with the smokeless-powder charge

was, however, to be anticipated on account of its reduced weight. A difference in the same direction is shown in the computed recoils, although the latter are considerably greater than the dynamometer records, on account of the probable inaccuracy of this instrument, and also because, in using the dynamometer, the attached spindle practically increased the weight of the rifle in recoil from 8.8 to 12.45 pounds.

The recoil of the .30-caliber rifle, measured with this dynamometer, using charges of various smokeless powders of approximately equal weight, is about 5 foot-pounds. The different smokeless powders produced practically an equal recoil, and it appears that, in whatever way a comparison may be instituted, the recoil of this rifle is shown to be less than one-half that of the .45-caliber rifle. The higher muzzle velocity of the .30-caliber bullet (2,000 *versus* 1,300 f. s.) is secured without material effect upon the recoil of the rifle by a better utilization of the force of the powder than in the .45 caliber, owing to the relatively increased length of bore, the travel of shot in the two rifles being, respectively, about 92 and 69 calibers. The chief cause of the lighter recoil is, however, the reduction in relative weight of powder charge and bullet. The weight of the two rifles is practically the same (8.8 pounds nearly), whilst the aggregate weight of charge and projectile is reduced to about 257 grains in the .30-caliber rifle as against 570 grains in the .45 caliber.

The weight of powder charge has a most important influence upon recoil, not only as affecting the weight (projectile and charge) which moves forward in the bore, but also the maximum velocity of the piece in its rearward movement. Under conditions of unrestrained recoil, the maximum velocity of recoil is acquired after the projectile has left the muzzle of the rifle; the powder gas continues to act upon the bottom of the bore for a certain time longer, still increasing the velocity of recoil, and in proportion to the mass of the charge (see footnote to Appendix 14). The ballistic advantages of smokeless powder are to be attributed to complete combustion and the volume of gas generated at high temperature, whereby a much lighter charge than of black powder is required to produce the same muzzle velocity in a given projectile. The reduced energy of recoil with smokeless powder for a given gun and equal muzzle velocity is not to be attributed to the more progressive action of the powder pressures in the bore, but to the lighter weight of powder charge. It may be said, however, in the case of a small arm, that the sensation of shock upon the shoulder of the firer should be ameliorated in proportion as the maximum pressure is less suddenly developed and the acceleration of velocity of projectile in the bore from seat to muzzle becomes more nearly uniform. In this respect, also, smokeless powders present a decided advantage over the black rifle powder, when the conditions of loading are properly regulated.

ARMAMENT OF FORTIFICATIONS, ETC.

Cannon powders.

Brown powders.—The test of the type 10 and 12 inch B. L. rifles, steel, has been continued during the past year, but the progress made towards completing the tests is far from satisfactory. This has been due in part to the delays occasioned in transferring the guns from one experimental carriage to another, in order to utilize the firings for the test of the carriages; but by far the most serious source of delay has been in the failure of the powder-makers to furnish satisfactory powders, or rather to *reproduce* a satisfactory powder when once such powder had been obtained. A large number of lots of powder have been manufactured for the test of the 12-inch rifle. Of this number, the fifth lot filled the ballistic requirements for the gun. After that it was not until after the eighteenth lot had been delivered that a powder was obtained that gave any close approximation to the fifth lot. The seventeenth lot, indeed, with a charge of only 350 pounds and a projectile of 1,002 pounds, gave the enormous chamber pressure of about 76,000 pounds per square inch, the normal charge for this gun being 450 pounds. Somewhat similar results have also been recorded for the 10-inch B. L. rifle.

Some of these high samples, when tested afterwards in the 8-inch B. L. rifle, proved much too quick, even for that caliber.

It is thus apparent that our powder-makers are as yet far from having the production of *brown* powder, for the larger calibers of guns, in such condition that the results of proof can be anticipated with any reasonable degree of certainty, and the incentive to obtain or perfect other suitable powders is increased. Strenuous efforts are being made to improve powders.

Smokeless powders—The investigation of smokeless powders has been prosecuted during the year. Samples of the best reputed foreign and domestic manufacture have been procured and subjected to analysis at the Frankford Arsenal and to ballistic tests at the proving ground. Every reasonable encouragement has been extended to inventors and producers of smokeless powders in this country; and orders have been placed with such powder-makers on the Atlantic and Pacific coast who are known to possess formulas for, and processes of, manufacture, for samples for trial with small arms and cannon. The following are some of the more important samples that have been tested at the proving ground during the year, viz: French B. N., for large guns and for field guns; German smokeless, U. S. Navy smokeless, Cordite, Troisdorf, and Leonard.

The results of tests of French B. N. powder for heavy guns, made last year with the 12-inch B. L. rifle, were noted in my annual report. Further firings, however, have since been made to ascertain the effect of storage upon the ballistic qualities of this powder, in order to ascertain

something as to its keeping qualities. The results are given in the following table, in which is given also the original firing record of this powder to permit of comparison:

Firings with 12-inch B. L. rifle.

[Kind of powder, French B. N.]

Date of firing.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Powder pressure in chamber.	Remarks.
	Pounds.	*Pounds.*	*Ft. sec.*	*Pounds per sq. in.*	
July 10, 1892	204	1,000	1,846	26,400	First lot fired; not stored.
Dec. 1, 1892	204	999	1,957	28,000	Stored in ordinary powder barrels since Aug. 5, 1892.
July 25, 1893	197	1,000	1,922	29,000	Stored in ordinary powder barrels since Aug. 5, 1892; had shrunk in storage from 200 pounds.
Aug. 8, 1893	204	1,000	1,895	26,600	Hermetically sealed since Aug. 5, 1892.

It will be observed that when this powder had been stored for four months the velocity increased 111 feet and the pressure 1,600 pounds. In a year a charge of 200 pounds had shrunk to 197 pounds, and yet gave 76 feet more velocity and 2,600 pounds more pressure than 204 pounds had given before storage. Hermetically sealed, the velocity increased 49 feet; pressure about the same as when first tested.

In considering these results, however, it should be borne in mind that the comparison is made from single rounds, and too much stress must not be laid upon them as quantitative determinations.

Upon the whole, the results obtained with this French powder may be regarded as quite satisfactory, and the fact that nitroglycerine does not enter into its composition is, according to present predilections, a strong point.

Reference is made in my annual report for 1891 to samples of German smokeless powder tested in the 8-inch B. L. rifle; and in my annual report for 1892 to the results obtained after exposing this powder to a high temperature. Some further firings have been made during the year to ascertain its keeping qualities when stored.

The following table gives a summary of the principal results obtained, with this latter object in view:

8-inch B. L. rifle.

[Kind of powder, German smokeless.]

Date of firing.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Pressure in powder chamber.	Remarks.
	Pounds.	*Pounds.*	*Ft. sec.*	*Pounds per sq. in.*	
July 24, 1891	45	300	2,000	30,100	First lot fired; not stored.
July 26, 1892	45	300	1,949	29,900	Stored in ordinary barrels since Aug. 29, 1891.
Do.....	45	300	1,968	30,400	Hermetically sealed since Sept. 1, 1891.
Mar. 21, 1893	45	300	1,973	30,100	Do.
Aug. 28, 1893	45	300	1,933	32,400	Stored in metallic cases, but not sealed, since Sept. 1, 1891.

The above results show a loss of velocity of about 67 feet during the period of nearly two years when the powder was stored in ordinary barrels, the pressure remaining about the same. This loss of velocity is not an objection of much moment, as it is the intention to store brown and smokeless powders in hermetically sealed cases for service. The cubical form of grain of this powder, as heretofore pointed out, greatly facilitates making up the cartridge. This is a marked advantage in its favor. On the other hand, the powder contains nitroglycerine, and objection has been raised to the use of this substance in smokeless powders. Whether this objection is well founded or not the Department is unable either to affirm or deny, owing to the limited experience it has had in the test of nitroglycerine powders. So far as these experiments have gone nothing detrimental to the use of this substance has developed.

The following table exhibits the mean results obtained with the various samples of smokeless powders in 5-inch guns:

ARMSTRONG 4.7-INCH R. F. GUN.

[Travel of shot in bore, 36.9 calibers.]

Kind of powder.	Number of rounds.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Pressure in powder chamber.
		Lbs. *Oz.*	*Lbs.*	*Ft. sec.*	*Lbs. per sq. in.*
Cordite	2	5 8	45	2,229	31,500

5-INCH UNITED STATES SIEGE RIFLE.

[Travel of shot in bore, about 24 calibers.]

Troisdorf	1	6 10	45	2,049	33,200
Do	1	6 12	45	2,071	37,500

5-INCH BROWN SEGMENTAL WIRE GUN.

[Travel of shot in bore, about 34.3 calibers.]

Leonard	1	15 0	63	2,397	32,800
Do	1	17 0	63	2,521	35,100
Do	1	21 0	63	2,874	46,600

The powders named in the above table, except the Troisdorf, are, it is believed, nitroglycerine compounds. The results obtained with the Leonard powder, which is an American powder, are very remarkable. The tests of this powder thus far made in field and siege guns have been mainly for the information of the inventor in its development, and only sample lots have been produced. No tests have as yet been made to determine its stability or keeping qualities under various conditions of storage.

The Department has taken a special interest in this powder from the outset; and every facility and encouragement has been accorded the inventor that could be of service to him in perfecting its qualities.

Cordite has been definitely adopted in England for certain calibers of rapid-fire guns, and experiments are now in progress to determine its fitness for guns of large caliber. Somewhat contradictory statements have been published as to its stability, owing to the nitroglycerine in its composition. It would seem, however, that the English Government has evidence of a satisfactory nature on this point. The sample of Troisdorf powder was obtained through our military attaché at Vienna. Its keeping qualities have not yet been tested, but it is only slightly affected by heat, and the ballistic results obtained with it are quite uniform.

The following table gives some representative results obtained in field guns with some of these types of smokeless powders:

3.2-INCH B. L. FIELD GUNS.

Kind of powder.	Number of rounds.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Pressure in powder chamber.	Remarks.
		Lbs. Oz.	*Lbs.*	*Ft. sec.*	*Lbs. per sq. in.*	
French B. N. for field guns.	8	1 14	13.5	*1,678	20,075	*This is about service velocity with black powder.
	6	2 8	13.5	2,065	*34,000	*This is about the service limit of pressure.
	1	2 9	13.5	2,105	36,100	
U. S. Navy	3	3 0	13.5	1,742	24,533	
Troisdorf Austrian.	2	1 8	13.5	1,660	24,450	
	5	1 14¼	13.5	1,938	34,460	

GERDOM 3.2-INCH GUN (AXIAL VENT).

Leonard	1	1 8	13.5	1,817	21,700	Tubular N—$\frac{7}{16}$ inch.
	1	2 2	13.5	2,217	32,000	
	1	2 3.5	13.5	2,257	36,500	
	1	2 12	13.5	2,273	35,900	Tubular N—$\frac{5}{8}$ inch.

SERVICE 3.2-INCH GUN (RADIAL VENT).

Leonard	1	2 8	13.5	1,750	18,800	Solid N—$\frac{5}{8}$ inch.
	1	2 0	13.5	2,145	33,100	Tubular K—$\frac{7}{16}$ inch.

It will be observed that the Leonard powder holds the same marked preëminence in these field-gun firings that it did with the 5-inch guns.

The sample of navy powder recorded in the table does not appear to have been well adapted to a gun of such small caliber as 3.2-inch, as it was found in the firings that much of the charge was thrown out of the gun unconsumed.

In the course of the firings with the Troisdorf powder experiments were made to determine the effect of changing the dimensions of the cartridge upon the ballistic results.

It was found that for equal weights of charge much lower pressures were obtained with the cartridge extending the whole length of the chamber than when a short cartridge of larger diameter was used.

The results obtained with the latter form varied also with the position of the cartridge in the chamber.

A full description of these tests of smokeless powders is given in Appendix 30 to this report.

In considering the results which have been obtained in the development of smokeless powders for cannon it should be observed that besides the uncertainty, which as yet exists, respecting the stability of these compounds, a new objection to their use is raised abroad. It is stated, on the authority of European manufacturers, who have now had a number of years' experience in the manufacture and test of smokeless powders, that the high heat evolved in their combustion, particularly of the chemically combined smokeless powders, fuses and corrodes the metal at the surface of the bore, and, perhaps, even alters the molecular condition of the steel. As a result the life of the gun is, it is claimed, materially shortened. That is to say, very high ballistic requirements can only be attained at the expense of a correspondingly rapid deterioration of the gun. If this be true, and the Department has no evidence to the contrary, the evil may be in a measure remedied by the use of a thin lining tube, to replace the worn-out metal next the bore and renewing it from time to time, in the same way as it is proposed to provide against the erosive action resulting from the use of brown powder. But lining, or relining, a gun, where a suitable initial compression of the liner must be secured, is a troublesome and inconvenient operation, and will be attended with considerable expense—particularly where the guns have been sent out into the service—so that the operation should be restricted to as few repetitions as possible. An alternative would be to lower the ballistic requirements and accept results more nearly approaching those obtained with brown powders.

SEACOAST GUNS.

For reasons already given the 12-inch B. L. rifle, type, has been fired up to date only 92 rounds, and the 10-inch B. L. rifle, type, 210 rounds. The 8-inch gun, type, manufactured at Watervliet Arsenal, has been fired 225 rounds.

The manufacture of seacoast guns at the gun factory and by contract has proceeded satisfactorily during the year, and at the end of the present calendar year the Department should have completed the following guns, including type guns:

Place of manufacture.	8-inch guns.	10-inch guns.	12-inch guns.
Army Gun Factory	25	20	9
West Point Foundry	8	.....	.....
Bethlehem Iron Works	1	.....	.....
Total	34	20	9

By the act of February 18, 1893, a further expenditure of $600,000 was authorized for the purchase of steel-gun forgings, and contracts were accordingly made as follows:

Place of manufacture.	8-inch guns.	10-inch guns.	12-inch guns.
	Sets.	*Sets.*	*Sets.*
Midvale Steel Works	9	.....	.....
Bethlehem Iron Works	.....	7	8

The tube of one of the sets of 12-inch forgings to be furnished by the Bethlehem Iron Company is to be of nickel steel and to be 40 calibers in finished length. The abnormally heavy pressures encountered in the test of the heavy type guns, using brown powder, point to the necessity for having very strong walls in the gun to resist such pressures; otherwise serious deformation, or even rupture, may result. As respects also some samples of smokeless powder tested in the rapid-fire guns the same observation is true. Hence there seems to be no warrant at present for making any reduction in the thickness of our guns over the chamber, notwithstanding it is somewhat greater than in some of the more recent types of guns designed abroad for the use of modern powders.

The following table shows the number of sets of forgings which have thus far been contracted for, since 1888, and includes the deliveries made under the contracts:

Table showing number of sets of 8-inch, 10-inch, and 12-inch forgings contracted for up to June 30, 1893.

Name of contractor.	Date of contract.	Number of sets of forgings.			Date of completing deliveries.		
		8-inch.	10-inch.	12-inch.	8-inch.	10-inch.	12-inch.
Bethlehem Iron Co.	Jan. 31, 1889	23	23	15	Apr. 21, 1891	Feb. 24, 1892	Nov. 15, 1893
	Sept. 26, 1892	....	12	10	.....	Aug. 22, 1894	Dec. 25, 1894
	June 24, 1893	....	7	8	.....	Sept. 24, 1894	Apr. 1, 1895
Total	.....	23	42	33			
Midvale Steel Co.	June 15, 1891	12	14	9	Aug. 16, 1892	Oct. 16, 1894	Dec. 16, 1896
	Sept. 19, 1892	10	....	....	Aug. 3, 1893	.....	.....
	June 22, 1893	9	....	....	Feb. 22, 1894	.....	.....
Total	.....	31	14	9			
Aggregate	.....	54	56	42			

EXPERIMENTAL GUNS.

Twelve-inch B. L. rifle, cast iron, tubed with steel.—The test of this gun has been completed during the past year at the hands of the Board for Testing Rifled Cannon, etc. The total number of rounds fired was 263, the weight of charge varying from 245 to 275 pounds, depending upon the quality of the powder. The weight of the projectile was

about 800 pounds. The maximum chamber pressure was limited to about 31,000 pounds per square inch. The velocities ranged from 1,725 to 1,750 feet at the muzzle. At a range of 3,000 yards, for a target of six shot, the results were as follows:

	Feet.
Mean vertical deviation from center of impact	2.5
Mean horizontal deviation from center of impact	2.17

At the conclusion of the test the bore showed marked erosions from the action of the powder, but still not of so serious a character as to cause the gun to be regarded as unserviceable. The erosion was much less marked also than in the simple cast-iron 12-inch rifle after the latter had been fired only 137 rounds, thus showing the advantage of the steel-lining tube for the preservation of the bore from erosion.

This 12-inch tubed cast-iron gun and the 12-inch hooped and tubed cast-iron gun were manufactured under the provisions of the fortifications act of March 3, 1883. Their construction was recommended to Congress by the Department at a time when the manufacture of reliable gun steel in large masses was in its infancy, and when the immediate establishment of a large steel plant in this country was not contemplated. The object of the Department was to develop a type of gun of greater power than the cast-iron smooth bores of the then existing sea-coast armament. In order to utilize materials within its reach it was decided to make the bodies of these guns of cast iron, taking advantage in this respect of the high quality of American gun iron. One of the guns was to be strengthened over the breech by means of a short lining tube, the production of which could readily be undertaken in this country at an early date. The other gun was to be reinforced by two layers of hoops over the breech, in addition to a short lining tube. To expedite manufacture the lining tubes were procured from Sir Joseph Whitworth & Co., Manchester, England. The steel hoops were manufactured by the Midvale Steel Company on their tire mill; and that company also furnished the forgings for the breech mechanism. The ballistic results obtained with the guns were a tremendous advance on the power of the 15-inch smooth-bore guns. Indeed, the energy was about equal to that obtained with the old short Krupp 12-inch steel rifle in use prior to 1880. As compared with modern steel rifles of 12-inch caliber, however, they fall very far behind, and can be regarded as only of medium power. The weight of these built-up cast-iron guns is 54 tons; that of the new 12-inch steel gun is 52 tons. The muzzle energy of the cast-iron gun is only about 17,000 foot-tons—about that of the new 10-inch steel gun—as against 27,000 to 30,000 foot-tons of the 12-inch steel guns. Again, the enormous weight of metal in the cast-iron bodies strained to the utmost limit the resources of the founder's art. Three out of four castings for one of these two 12-inch guns were lost during manufacture.

In view of all these considerations, and, further, of the fact that high-powered steel guns are now being rapidly produced in this country, of

domestic steel, unsurpassed in quality, I concur in the opinion of the board not to recommend this type of gun for use in the service.

Woodbridge 10-inch wire gun.—This gun was commenced under the provisions of the fortifications act of March 3, 1883. The tube and trunnion hoop were procured from Sir Joseph Whitworth & Co., Manchester, England. The wire is of domestic manufacture, the billets being produced by the Otis Iron and Steel Company, of Cleveland, Ohio, and the wire drawn at the Trenton Iron Company's works, Trenton, N. J. The steel bars for the longitudinal staves were cold rolled at the works of Jones & Laughlin, Pittsburg, Pa. The breech mechanism and smaller forgings were furnished by the Midvale Steel Company. The work of manufacture was taken in hand at the Watertown Arsenal, some special plant and appliances having been provided there for the purpose. The gun was completed at Watertown, except as to its breech mechanism and finishing and rifling the bore, which work was done at the army gun factory, Watervliet Arsenal.

Great delays have occurred in the manufacture of this gun, owing to difficulties in procuring some of the material of the proper quality and to the failure of the necessary appropriations for continuing the work. The necessary funds to complete the work were finally allotted by the Board of Ordnance and Fortification. The gun is now at the ordnance proving ground and is about to be subjected to the usual preliminary proof and experimental firings, after which it will be turned over to the Board for Testing Rifled Cannon, etc.

Crozier 10-inch wire gun.—The manufacture of this gun was undertaken under the provisions of the act of September 22, 1888, and Watervliet Arsenal was selected as the place of manufacture. Great and unavoidable delays have occurred in procuring part of the material, more especially the jacket, which, according to the design, was to be of cast steel. After numerous failures, however, to procure a satisfactory casting, it was decided to substitute for it a jacket of forged steel, which was readily obtained. It is quite probable that with the increased facilities for manufacture recently put up at the steel works a suitable cast-steel jacket could be obtained at this time without very great difficulty. The gun is nearly completed and will be sent to the ordnance proving ground during the present month.

BROWN SEGMENTAL WIRE GUN.

A 5-inch B. L. rifle on this system, which had been under manufacture for several years at Reading, Pa., was completed and submitted for test during the summer by the Brown Segmental Wire Gun Company, and the gun has been subjected to partial test at the ordnance proving ground. The nature of the construction is generally described by the company's engineer as follows:

> The gun consists essentially of a segmental core wound with wire under such tension that the compression between the longitudinal segments of the core induced thereby will be more than sufficient to resist all ordinary powder pressures.
>
> The trunnions are not attached to the core or body of the gun, but to an outer

trunnion jacket, which jacket is attached to the gun proper by means of the breech nut. The breech block engages in a bushing which is screwed into the trunnion jacket. By this means the recoil is transmitted to the trunnions through the bushing and jacket, and the core or body of the gun is thus relieved from the major part of the longitudinal thrust due to powder pressure upon the bottom of the bore.

The gun itself is free to expand longitudinally within this jacket, which is attached only to the breech nut.

A thin steel lining tube extends from the bottom of the bore forward to a point about four and one-half calibers in front of the chamber, the object of which is to provide against the erosive effect of the powder gases upon exposed joints of the segments in the part of the gun where the pressure is greatest. This lining tube is removable.

The wire wrapping over the chase of the gun is covered with a thin sheathing of metal.

The length of the gun is 44 calibers; travel of shot in bore, 34.5 calibers; weight of piece, 9,310 pounds. The capacity of the chamber is such as to contain a charge of 35 pounds of powder with density of loading unity. The weight of the projectile is 62 or 63 pounds. The normal powder pressure in the chamber was fixed at 52,000 pounds. To resist so high an interior pressure required a correspondingly high initial compression of the segmental bars to prevent the joints from opening in firing, and that in turn necessitated very high qualities in the metal in order that the elastic limit should not be exceeded. The same is true for the steel lining tube, which, although it is inserted under an initial compression, is required to work between such wide limits that very high elastic qualities are necessary. The elastic limit actually obtained in the metal of this lining tube was about 112,000 pounds per square inch; the metal in the steel segmental bars showed about the same quality. The attainment of these high qualities, even in such comparatively small masses of metal, was attended with difficulty, causing the expenditure of much time and labor. The resulting estimated resistance of the gun to interior pressure, before opening would occur at the joints, is about 63,000 pounds per square inch.

In allotting funds for the test of this gun up to 100 rounds the Board of Ordnance and Fortification imposed the following requirements as to pressures: 20 rounds with a pressure of 40,000 pounds; 60 rounds with a pressure of 50,000 pounds; 20 rounds to be utilized in experimental firings.

Under these requirements the gun has thus far been fired 21 rounds with pressures of 40,000 pounds; 35 rounds with pressures exceeding 40,000 but less than 50,000 pounds, and 20 rounds with pressures of 50,000 pounds. Total, 79 rounds.

The gun has been fired, however, up to date, about 100 rounds, of which 21 rounds have been fired at the expense of the company.

Some of the best results obtained in these firings are as follows:

With brown powders:

Charge, 38 pounds; projectile, 62 pounds; muzzle velocity, 2,265 feet; pressure, 33,400 pounds per square inch.

Charge, 41 pounds; projectile, 62 pounds; muzzle velocity, 2,408 feet; pressure, 48,330 pounds per square inch.

It was observed with brown powders that the increase of velocity for pressures above 40,000 pounds was relatively much less than had been anticipated.

With Leonard smokeless powder:

Charge, 17 pounds; projectile, 63 pounds; muzzle velocity, 2,521 feet; pressure, 35,100 pounds.

Charge, 21 pounds; projectile, 63 pounds; muzzle velocity, 2,874 feet; pressure, 46,600 pounds.

The remarkable character of this Leonard smokeless powder is alluded to under the head of smokeless powders for cannon. The experiments have not as yet been carried far enough, however, to determine its stability and suitableness for service, or the effect of the heat, evolved in its combustion, upon surface of the bore. It is said to contain a high per cent of nitroglycerine.

As a result of the tests thus far made, the Board of Ordnance and Fortification has allotted sufficient money for continuing the test up to 500 rounds.

As respects the results obtained with this gun, it may be stated, generally speaking, that, neglecting differences due to greater length of travel of shot in bore, weight of charge, and lightness of projectile, as compared with our service guns, the main factor of effect in the ballistic results, for a given powder and form of cartridge, is the *high pressure*. Whether such pressures are desirable with guns of large caliber is to be questioned, as it is generally conceded among artillerists that the erosive action of the powder gas increases rapidly with the pressure. Even if the tests should prove that such pressures are admissible, it is questionable whether the high qualities of metal demanded in this system of gun construction can be attained in guns of large caliber, except at an expense that would be prohibitive of their manufacture.

With the more usual type of built-up construction, on the other hand, such, for instance, as the type adopted for our service guns, in which the central core is a tube without joints and possessed of tangential resistance in itself, the required elastic resistance of the gun is obtained with a quality of steel that is readily produced in current manufacture, and would be, even if the resistance should be raised to the limit fixed for the Brown segmental gun. This results from the fact that the elastic limit of the metal in the tube need equal only about three-fifths that of the segmental bars to give the same elastic resistance in the gun. The 8, 10, and 12 inch service guns are assembled under the conditions that the elastic limit of the tube is about 39,000 pounds; of the jacket about 41,500 pounds, and of the hoops from about 47,000 to 50,000 pounds, and the resulting elastic resistance of the gun is about 53,000 pounds. These qualities of steel are considerably exceeded in actual manufacture, and by substituting nickel steel for the tube, as is

to be done in the 12-inch rifle of model 1892, the elastic resistance of the gun may be carried to nearly 63,000 pounds. By the substitution of nickel steel in the jacket, also, the elastic resistance may be carried to beyond 67,000 pounds, and yet without putting any special strain on the manufacturers to produce the requisite qualities in the metal.

The merits, or demerits, of this system, as compared with the service system of construction, are well stated by Capt. Rogers Birnie, Ordnance Department, in his comments on the 5-inch segmental gun, in a paper entitled "Gun construction and breech mechanism," read before the Engineers' Congress at the Chicago Exposition, last August, as follows:

It (the segmental gun) is subjected to an initial compression by the wire envelope which does not exceed the elastic limit of the metal, and is estimated to be more than sufficient to prevent the joints from opening under a powder pressure of 52,000 pounds per square inch. In effect the maximum resistance of the gun or the pressure which will reduce the compression between the bars at the surface of the bore to zero—thus falling short of opening the gun—is, as estimated by Lieut. Whistler, 63,500 pounds per square inch.

It is to be observed that this maximum of resistance is given for an estimated compression of 103,000 pounds per square inch between the bars, and that this state of compression is never (can not be) relieved, and therefore the elastic strength of the metal is utilized in only one direction instead of through the double range, as would be admissible if the core, instead of being made a segment, were a solid cylinder. The construction is uneconomical in the sense of utilizing the high elastic properties of metal present; that is to say, it has been necessary in making a gun of so many parts to use metal of far higher physical qualities than would be required to secure the same tangential resistance in another and less complicated way. Thus, the wall of gun over the powder chamber has a thickness of about 1.17 calibers. If made with a solid tube, the tangential resistance, from formula (2), would be represented by

$$P = 0.653\ (\rho + \theta)$$

"If $\theta = \rho = 103{,}000$ (as given for the segments) we should have $P = 134{,}500$. It is not reasonable to suppose that simple cylinders of large dimensions can be made with such high elastic properties, but if P be fixed at the given value, 63,500 pounds, we find:

$$(\rho + \theta) = 97{,}220 \therefore \rho = \theta = 48{,}610,$$

showing that if a gun of the same caliber and dimensions as this were constructed of simple cylinders shrunk together, as in the forged cylinder construction, an elastic limit of about 50,000 pounds per square inch would be required in the metal to give about the same tangential resistance. And if a metal having an elastic limit of 66,000 pounds were provided, this construction would give a radial resistance of 63,500 pounds, and meet every requirement of principle.

MORTARS.

Twelve-inch B. L. mortars, steel.—The test of the 12-inch B. L. mortar, steel, has been continued during the year to a limited extent, but, owing to the repeated breaking down of the carriage improvised for the tests, not much progress has been made. By reason of the comparative lightness of this piece, in respect to the weight of its projectile, unusually heavy strains are impressed upon the carriage in firing,

and neither the carriage for the 8-inch gun nor that for the 10-inch gun was found to possess sufficient resistance. The gravity-return mortar carriage, on the other hand, proved unsuitable, owing to the great height of the top carriage; but, when no other resource remained, it was decided to cut down the height of this carriage until only a few degrees of elevation could be given to the mortar. In this way a suitable carriage has been obtained for butt firings.

This steel mortar has been fired fifty-six rounds, and, now that a carriage and suitable powder have been obtained, the tests will be pushed to completion without delay. For high-angle firing, such as will be alone used in the service of these mortars, it has been ascertained that the new spring-return mortar carriage can be used with this piece satisfactorily. The Department has under manufacture at the gun factory seven steel mortars similar in design to this type mortar, which will be completed during the coming year.

Twelve-inch B. L. mortars, cast-iron, hooped.—At the end of the calendar year forty-three of these mortars will have been completed under present contracts, making, with those completed under previous contracts, seventy-three mortars of this type. Congress failed to make any appropriation at its last session for continuing the manufacture of 12-inch mortars, either of steel or of cast iron hooped with steel. Unless some action is taken, in this respect, at its next session, the manufacture of this most useful and economical arm of coast defense will be at a standstill.

GUN CARRIAGES.

The 8-inch barbette carriage, noted in my last annual report as under fabrication at Watertown Arsenal, has been completed and tested at Sandy Hook during the past year. The top carriage is made of bronze, but hereafter cast steel will be used for that purpose. The chassis and roller circles are of cast iron. Firings were made at 7° depression and 18° elevation. During the test many minor defects developed, and changes were indicated which have been embodied in the construction of seven other carriages which are now being built at Watertown Arsenal. A description and drawings of this 8-inch barbette carriage are given in Appendix 28 to this report.

There are also under manufacture at the Watertown Arsenal five 10-inch barbette carriages and four 12-inch barbette carriages, all non-disappearing; also two 12-inch gun-lift carriages. These carriages are of the type known as gravity return, and in general design are similar, except that the gun-lift carriage has a special automatic arrangement of its hydraulic cylinders to retain the gun in its recoiled position after firing, and that the chassis and upper roller path are of cast steel and in two pieces for all calibers except the 8-inch barbette carriage. The lower roller path is of gun iron in all the carriages.

Disappearing carriages.—The experimental 10-inch pneumatic carriage has passed the test prescribed by the Board of Ordnance and

Fortification for its acceptance, and this carriage has been paid for and turned over to the Department for such additional tests as it may deem desirable to make to determine the fitness of the carriage for service.

The Gordon experimental 10-inch disappearing carriage has been completed, and is now undergoing some preliminary firing at the ordnance proving ground to test its general working and to determine what modifications may be necessary before it is turned over to the Ordnance Board for the regular test.

Buffington-Crozier 8 and 10 inch carriages.—The 8-inch Buffington-Crozier disappearing carriage has been completed at the works of the Southwark Foundry and Machine Company, at Philadelphia, Pa., and is now being set up for test at the Ordnance Proving Ground, where its platform has been for some time in readiness.

The 10-inch carriage on the same system should be completed in November next.

Work on the carriages has been much delayed, owing primarily to the incomplete equipment of the manufactories of the country at the time of their commencement for the production of the large steel castings required.

ALTERATION OF CARRIAGES.

The usual work of altering 15-inch smooth-bore carriages for use with increased charges of powder has been carried on at the Watertown Arsenal during the past year, and the alteration of nine 15-inch carriages and nine 10-inch barbette carriages will be completed during the present calendar year.

The fortifications act of February 18, 1893, appropriates $50,000 for continuing this work, and thirteen additional 15-inch carriages will be taken in hand at once for alteration.

MORTAR CARRIAGES.

To provide carriages for the eighty 12-inch mortars, which will be completed by the end of next year required very earnest efforts on the part of the Department to awaken an interest in the work among responsible manufacturers; besides, some long-continued negotiations with the owners of the patent rights of the spring-return mortar carriage were necessary in order to secure reasonable prices thereunder. As a result the following contracts have been placed during the past year upon very satisfactory terms as respects price and time of delivery:

Place of manufacture.	Date of contract.	Number of carriages.	Date of completion.
Builders' Iron Foundry, Providence, R. I.	Feb. 20, 1893	28	Apr. 8, 1894
Robert Poole & Son Co., Baltimore, Md	....do	36	July 5, 1894
West Point Foundry Co., Cold Spring, N. Y	Apr. 17, 1893	7	Oct. 12, 1894
Total	.....	71	
On hand, manufactured under previous contracts	.....	9	
Total	.....	80	

By the substitution of coil springs for the Bellville springs in these carriages some economy in construction has been attained and a much greater certainty secured in the production of reliable springs. The Department has placed a contract for the manufacture of a mortar carriage for test, which is a modification of the present design of spring-return mortar carriage. This design promises to simplify the construction and reduce the cost of manufacture.

Minimum-port casemate carriage.—This carriage, under manufacture at the Grusonwerk, Magdeburg-Buckau, Germany, has been completed and shipped, and arrangements are being made for mounting it at the ordnance proving ground for test, where it will soon be received.

PROJECTILES.

Armor-piercing shot.

The act of February 18, 1893, contains an item of $40,000 for the purchase of armor-piercing shot, under which a contract was made with the Carpenter Steel Company, of Reading, Pa., for 100 12-inch armor-piercing shot, to be delivered in about eight months. The total number of shot thus far contracted for is as follows:

Place of manufacture.	8-inch.	10-inch.	12-inch.
Midvale Steel Co.	312	422	148
Carpenter Steel Co.	.....	.....	100

The first lots of 8 and 10 inch shot under the Midvale Steel Company's contracts have been delivered and tested, and with results that are highly satisfactory. The plates of $1\frac{1}{8}$ calibers thickness were perforated without the projectiles undergoing any material deformation.

Deck-piercing shell.

A contract was placed with the Sterling Steel Company, of Pittsburg, Pa., in January last for a quantity of deck-piercing shell for use with the 12-inch mortars. Several lots have been furnished under this contract, and while the ballistic tests were very fair, the manufacture has not as yet reached the high standard required for piercing the heaviest decks of modern war ships without the breaking up of the projectile. But with the experience that has now been gained in the manufacture and test, it is expected that the manufacturers will soon be able to produce projectiles fully up to the standard of the requirements. The present requirements are that the projectile shall perforate a 4.5-inch steel deck plate, at an angle of 60° with the horizon, without breaking up or material deformation.

It is the purpose of the Department to supplement the deck-piercing shell with another type of shell for the service, this shell to be of steel with very thin walls and capable of holding a large charge, say, 100

pounds or more of gun cotton or emmensite, and armed with a quick-action fuse, designed to burst upon impact; the object of such explosion on the steel protective deck of ships being to destroy the personnel and batteries located above that deck, to shatter the deck, and project fragments below.

Zinc powder cases.

In 1886 a number of zinc powder cases were manufactured at the Rock Island Arsenal and issued to the ordnance proving ground. These cases consisted of sheet zinc cylinders, lined with straw board, the bottom being reinforced with a disk of wood. The top, or lid, was furnished with handles for carrying the case, and was screwed into place in the case, the joint being sealed by means of a copper packing ring. A powder case similar to the above in general respects has been made recently by the commanding officer of Rock Island Arsenal, and it has been adopted for the service, and cases are now being made at that arsenal for the 8, 10 and 12 inch steel seacoast guns and 12-inch mortars. The handles of this case are so designed as to admit of piling the cases in the magazine in tiers, on end, if desired; the cases are also made sufficiently strong to admit of piling them in tiers, placed on their sides. Different sizes of cases are required for the different guns, but the capacity has been so regulated as to hold some aliquot part of the full charge, as one-half, one-third, etc.

For description of these cases see Appendix 26 to this report.

PNEUMATIC DYNAMITE GUNS.

The financial difficulties of the company which undertook to supply these guns were alluded to in the last report. Since that time a reorganization has been effected and the present company has been progressing rapidly with the work.

The company is to deliver one 8-inch and two 15-inch guns with suitable projectiles for trial at Sandy Hook, N. J., by January 27, 1894, and three 15-inch guns at Fort Winfield Scott, Cal., with projectiles for trial by July 27, 1894.

The guns are to be set in place by the company with their carriages, projectiles, the necessary machinery, appurtenances, and accessories, properly and securely placed on adequate foundations, all complete, so that they may be operated, handled, fired, and be entirely ready for military use.

Payment for each group of guns, or for each gun mounted, is to be made on delivery and acceptance, less 5 per cent to be retained until completion of the contract.

SIEGE MATERIAL.

The ten 5-inch B. L. rifles and ten 7-inch B. L. howitzers were completed at the gun factory during the past year, and ten more of each of these types have been placed under manufacture at that establishment.

The twenty carriages required for the 5-inch rifles, and noted in my last annual report as under manufacture at the Rock Island Arsenal, are not yet completed, but it is expected that they will be finished during the coming year.

The test of the experimental carriage for the 7-inch howitzer has been completed. A number of modifications in its construction were indicated during the trials; some of which it was necessary to apply to the experimental carriage before going on with the firings; and all the modifications are embodied in a new carriage which is under manufacture at the Rock Island Arsenal. As soon as this new carriage can be subjected to a limited test, the manufacture of a sufficient number to mount twenty howitzers will be taken in hand.

The 5-inch Raskazoff siege carriage referred to in my last annual report has been subjected to some test, but it was soon demonstrated that the carriage did not possess the necessary strength. At the outset of the test the trail was badly buckled. The carriage is, however, undergoing repair at the proving ground, after which the test will be continued.

A 7-inch steel B. L. mortar is under manufacture at the gun factory, and will be completed before next March. Work upon this piece has not been pushed for the reason that owing to the pressure of other work the design for the carriage was greatly delayed.

FIELD MATERIAL.

3.2-inch field guns, steel.—Congress at its last session reduced the usual appropriation of $25,000 for the manufacture of these guns to $15,000, which is sufficient for the manufacture of only fifteen additional guns, model 1890. When this last lot is completed, the Department will have one hundred and sixty-five 3.2-inch guns, of which number forty will be of model 1890, and the remainder of model 1885.

A number of carriages for the service of these guns are under manufacture at the Rock Island Arsenal, viz, 32 carriages and limbers, 32 caissons and limbers, and 9 combined battery wagons and forges.

Trials of smokeless powder for field guns have been continued during the year. Some of the samples tested have given very satisfactory results so far as the tests have been carried; but it can not be said as yet that the absolute merits of any of the samples have been definitely determined. These trials are referred to more fully under the head of smokeless powders, and the results are given in an appendix to this report.

A 3.2-inch gun, model 1890, was fitted with the Gerdom breech mechanism and tested during the year, using the usual service ammunition, with satisfactory results. This mechanism is now being fitted with a cartridge-case extractor and firing device to adapt it for use with metallic ammunition, and promises to make a very satisfactory type of field gun for use with metallic ammunition.

3.6-inch B. L. field guns, steel.—Twenty-four of these guns are under manufacture at the gun factory, and will be completed by next March. This type of gun constitutes the heavy field gun, and it is not probable that a very large number will be required.

3.6-inch B. L. field mortar, steel.—Sixteen of these 3.6 inch field mortars, noted in my last annual report as under manufacture, have been completed with their carriages and platforms, and will soon be issued to the service for the instruction of artillery troops.

Since the test of this mortar and its mountings some modifications have been made in the platform and equipments. The platform has also been strengthened by the introduction of wrought-iron side straps, bracing it sideways, and bolted to cross pieces, removing what had proved to be a source of weakness in the test.

MOUNTAIN MATERIAL.

Hotchkiss 3-inch B. L. mountain gun.—This gun has been subjected to the prescribed test of 1,000 rounds under the supervision of the Board for Testing Rifled Cannon, etc. A preliminary report was made on the test of this gun after firing 552 rounds, and published in the last Annual Report (see Appendix 41). At that stage of the test the board reported the performance of the piece as satisfactory, and that pieces of this type may safely be put to use in the service. This conclusion has since been confirmed in the final report of the board, but the board gives its opinion that some other form of breech mechanism may prove more satisfactory for service, and that a better quality of material should be used in the axle of the carriage.

The battery of four 3-inch mountain guns, ordered by the Department of the Hotchkiss Ordnance Company, has been delivered, and will shortly be placed in service.

SIEGE AND FIELD PROJECTILES.

The manufacture of common cast-iron shell for the siege and also for the field artillery has been continued in sufficient quantities to keep on hand the number required for the present needs of the service and a small reserve. Designs for steel shell adopted to fire charges of high explosives are under consideration, and it is hoped some of these shells can be obtained at an early date.

3.2-inch shrapnel.—Samples of 3.2 inch shrapnel for fixed ammunition have been made at the Frankford Arsenal and tested at the Sandy Hook Proving Ground for strength of construction. Five of the shrapnel were fired with a charge of 1 pound 13.5 ounces of Troisdorf smokeless powder, giving a chamber pressure of about 35,500 pounds. The sound of all the shrapnel was clear in flight and their accuracy (at 1,000 yards) indicated that there was no deficiency of strength. This shrapnel is of the same general construction as the 3.2-inch Frankford Arsenal shrapnel, model No. 1, with head charge as described in the

last annual report, but is longer and heavier, having a weight of about 16 pounds 10 ounces, and will give about 240 balls and fragments when exploded. The band is placed at a distance from the base sufficient to engage the shrapnel in the neck of the metallic cartridge case.

The 3.2-inch shrapnel of ordinary pattern, mentioned in the last annual report as under construction by the American Projectile Company, the Hotchkiss Ordnance Company, and at the Frankford Arsenal, have all been completed and delivered, and an order for 2,500 more, to be made at the arsenal, has been given.

The several improvements made in the construction of 3.2-inch electrically welded shrapnel under contract with the American Projectile Company are described in the reports, Appendix 40, herewith, in connection with the results of firing tests of the improved shrapnel. The revised specifications and drawing published in the same connection take the place of those contained in the last annual report. The improvements made in this shrapnel, which contains the bursting charge in the base, as distinguished from the others mentioned, wherein the bursting charge is in the head, render it a very satisfactory shrapnel.

3.6-inch shrapnel.—A satisfactory type of shrapnel for the 3.6-inch guns and mortars has been established and the shrapnel can be made in quantity as needed. The Frankford Arsenal 3.6-inch shrapnel here referred to is described in Appendix 39 in connection with reports of the firing tests for accuracy and for dispersion which have been made at the Sandy Hook Proving Ground.

1.65-inch ammunition.—The plant which is in process of development at the Frankford Arsenal for the manufacture of fixed ammunition for field and mountain guns was so far progressed as to enable the manufacture of about 200 cartridges, with common-shell projectile, for the 1.65-inch mountain gun during the past year, and an order for 2,000 rounds, to be made during the present year, has been given. The customary tests of this ammunition to establish its equality with that heretofore issued for the service of these guns have been in part completed at the proving ground with satisfactory results. The action of the fuse only remains to be tested.

FUSES FOR PROJECTILES.

The 15-seconds Frankford Arsenal combination fuse, model 1891, for shrapnel was issued for service during the year with the light batteries of 3.2-inch field guns. The manufacture of this fuse has been fully established, and now forms part of the regular annual output of the Frankford Arsenal. The difficulties met with in adapting the base percussion elements of the 28-seconds fuse of the same pattern to the degree of sensitiveness required for operating with the smaller charges of the 3.6-inch field mortar and yet be safe in transportation have led to continued experiments, which are still in progress.

Several designs of detonating fuses for projectiles with bursting

charges of high explosives have been prepared, and samples of these fuses are now under trial at the Sandy Hook Proving Ground.

With the near exhaustion of the supply of ordinary base fuses for breech-loading projectiles on hand opportunity has been taken to adopt two regular sizes of base fuse with left-handed pitch of thread suited to tighten the fuse when fired, in opposition to the right-handed pitch of rifling in the service guns. The smaller size of fuse is to be used for calibers under 5 inches, except the 3.6-inch field mortar, and the larger for calibers of 5 inches and upwards. The two sizes of thread (in projectile) are as follows: Small, 16 threads per inch, left hand; outside diameters, minimum 0.714 inch, maximum 0.717 inch. Large, 12 threads per inch, left hand; outside diameters, minimum 1.125 inches, maximum 1.128 inches. These will replace the threads of previous pattern, 16.8 threads per inch, right hand, for the smaller size, and 12 threads per inch, right hand, for the larger, and will be regularly issued when the limited supply of the latter on hand is expended. A quantity of the new sizes of fuse is now under manufacture. Field projectiles, both the common shell with base percussion fuse and sharpnel with combination point fuse, will habitually be issued, charged, and fused for service from the arsenals or depots of supply.

Fuse punch.—A description and drawing of the fuse punch adopted for service with the Frankford Arsenal point combination fuse for sharpnel is published in Appendix 41 herewith. The punch is adapted to cutting the time train of both the 15 and 28 seconds fuses of this pattern.

PRINCIPAL ESTIMATES FOR ARMAMENT OF FORTIFICATIONS FOR FISCAL YEAR ENDING JUNE 30, 1895.

The principal estimates for the next fiscal year, under the head of "Armament of fortifications," are as follows:

For field and siege material $114,900

To procure about twenty-five 3.2-inch field guns, steel, and their carriages, complete, and ten 7-inch B. L. steel mortars and their carriages.

For alteration of carriages $50,000

To provide for the alteration of about nine 10-inch S. B. carriages for use with the 8-inch converted rifle and nine 15-inch S. B. carriages for use with the 15-inch gun firing increased charges.

For steel armor-piercing shell for 12-inch B. L. mortars $50,000

Sufficient to procure about 200 shell of 800 pounds weight.

For steel armor-piercing shot $100,000

To procure about 200 12-inch shot.

For deck plates and armor plates for testing deck-piercing and armor-piercing projectiles, including cost of erection $36,000
For powders and projectiles for issue to service 165,000

To cover the manufacture of about 2,000 shrapnel and a quantity of cast-iron shot and shell and a limited supply of powder.

For oil-tempered and annealed steel for 8, 10, and 12 inch guns, including one set of forgings for 16-inch gun $1,023,000

Estimated to procure twelve sets of 8-inch forgings, twelve sets of 10-inch forgings, twelve sets of 12-inch forgings, and one set of 16-inch forgings.

For steel B. L. rifled mortars, 12-inch caliber $676,000

Estimated to procure about forty-eight mortars, or three groups of sixteen each, including forgings therefor.

For carriages for B. L. mortars of 12-inch caliber $360,000

To procure about forty-eight spring return carriages to mount the mortars mentioned in the preceding estimate.

For carriages for mounting steel B. L. cannon of 8 and 10 inch caliber. $430,000

Estimated to procure about five 8-inch and nine 10-inch disappearing carriages.

To meet payments that will become due under the provisions of the fortifications acts of July 23, 1892, and February 18, 1893, directing the purchase or manufacture of machinery, tools, and fixtures to complete the equipment of the army gun factory; for steel B. L. mortars, 12-inch caliber, oil-tempered gun forgings, and for carriages for mounting steel 8, 10, and 12 inch B. L. mortars $926,000

All of the money obligated by Congress under the said acts, and not heretofore appropriated, will be required during the coming year to meet payments that will fall due.

EXPERIMENTAL MATERIAL.

The "Peeler" rasp, made of a perforated plate of hard steel fitted to a frame, was issued for experimental trial. The reports received speak favorably of it as a rasp for preparing the hoof for the shoe, but they also indicate the necessity for using the ordinary rasp now issued for filing down the clinches, and in general the reports were adverse to increasing the number and weight of the farrier's tools to be carried. A new design has been submitted, which is now under trial. The Souther farm rasp was also tried, but was not thought to be adapted for the military service.

The Economic nosebag is yet under trial, as well as the Tilleston sure-fast girth attachment. A blanket-roll support, designed by Lieut. Dodge, will soon be tested in competition with the Merriam pack and the blanket-bag equipment. Various intrenching tools are now undergoing test, including the Babcock spade-hatchet, and the Luther, Patterson, and Kahan intrenching tools, the report on the latter not yet having been received.

Experiments are still being made at the Rock Island Arsenal to improve the lariat, and attempts have been made, so far unsuccessfully, to

obtain by the use of aluminium lighter articles of equipment in the way of canteens, cups, meat cans, picket pins, belt plates, bits, etc. Steel collars have been issued to each battery of light artillery, and reports generally indicate that they are very suitable for the military service. Serious defects have been found in the arrangement of the linchpin, washer, and nut of the carriage for the 3.2-inch field gun; but steps are being taken to remedy these defects, which it is thought will be successful.

MINOR CHANGES IN MATERIAL.

The saddle cloths for all officers have been made of the same dimensions.

The adjustable-girth attachment suggested by Capt. Godfrey has been adopted.

A new yoke-ring connection for 3.2-inch field-gun carriage has been adopted, which does away with the swivel eyebolt, washer, and bolt plates.

Curb bit, model 1892.—No change has been made in them, but their issue having been delayed in consequence of the difficulty of getting the proper quality of steel, reports as to their merits have not yet been received.

Fencing implements.—The new drill regulations prescribe their use, but as there were no appropriations for their manufacture they have not been issued to the extent desired.

ARTILLERY.

The front sight for the field gun has been modified in accordance with a suggestion made by Capt. J. B. Burbank, Third Artillery. A cross made of untempered steel ribbons halved at their intersection has been substituted for the wire cross formerly used. The arms of the cross are fixed in such a position as to make an angle of 45 degrees with the vertical.

The limber chests of field batteries have been supplied with partitions, adapting them to carry the shrapnel now being issued, and it is found that these partitions can be easily attached by the artificers of the battery.

WATERPROOF COVERING FOR FIELD CARTRIDGES.

In 1891 a number of cartridges were put up in cases made of linen treated with rubber—the ordinary waterproof rubber cloth of commerce. These cases were composed of a cylinder with a circular base, the edge of the cylinder being joined by a waterproof cement and the base secured to the cylinder by the same substance, and a cap made in the same manner. A rip string was cemented to the interior of the case, and after inserting the cartridge the cap was put on and held in place by cement. The cartridges thus put up were issued to posts, where they were packed in a limber chest, which chest was placed out

of doors. Posts were selected as regards climate, where the cartridges would be subjected to dry and to moist heat, and to dry and to moist cold. As a result it was found that the amount of deterioration was hardly perceptible after about eighteen months' storage. The greatest deterioration was at the proving ground, where, being on low ground and near the seashore, great dampness prevailed.

Horseshoes of light weight have been issued to the batteries for trial, and reports have been so favorable that they will be substituted for those now in service as soon as economic arrangements can be made for the disposition of the stock now on hand.

It has been found impossible to issue to artillery posts all the appliances required for mechanical maneuvers, important as these exercises are recognized to be in the education of artillery soldiers. The supply on hand has been gradually exhausted, and the appropriations for the purchase of new material have been insufficient to provide more than a limited supply to the most important posts.

Spring sponges have been designed and ordered manufactured at the Watertown Arsenal for the bore and for the chamber of the 8-inch B. L. rifle, the 10-inch B. L. rifle, the 12-inch B. L. rifle, and for the bore and chamber of the 12-inch B. L. mortar. While a chamber sponge will be issued to each of the B. L. rifles as mounted it is proposed to issue but one sponge for the bore for groups of four guns of each caliber.

I have the honor to submit herewith the following papers as appendices to this report.

Several of these appendices have already been referred to and quoted from in this report. I would invite attention to Appendix 14, on the test of smokeless powders for small arms; to Appendix 19, on the effect of small-caliber rifle projectiles upon animal tissue and bone; to a paper in Appendix 21, on overhead traveling cranes operated by electric motors; and to Appendix 30, on tests of smokeless power for cannon.

Appendices 43 to 48, inclusive, are several papers prepared chiefly by ordnance officers, on ordnance subjects, for the division of military engineering of the International Congress of Engineers, held at Chicago last summer. These papers were, with others, published in pamphlet form, for use of the Congress during its sessions, but they are of such professional interest and importance to the officers of this Department, the Army, and others to whom this report is sent, that I think it important they should be embodied in this report. They are valuable to this Department for reference.

Appendix 1.—Statement of principal articles procured by fabrication during the year ended June 30, 1893.

Appendix 2.—Statement of principal articles procured by purchase during the year ended June 30, 1893.

Appendix 3.—Statement of ordnance, ordnance stores, etc., issued to the military establishment, including the national homes for soldiers

of the volunteer and regular Army and exclusive of the militia, during the year ended June 30, 1893.

Appendix 4.—Statement of ordnance, ordnance stores, etc., distributed to the militia from July 1, 1892, to June 30, 1893, under section 1667, Revised Statutes.

Appendix 5.—Statement of ordnance, ordnance stores, etc., distributed to the colleges from July 1, 1892, to June 30, 1893, under section 1225, Revised Statutes.

Appendix 6.—Statement of arms and ammunition issued to the Executive Departments during the year ended June 30, 1893, under the provisions of the act of March 3, 1879.

Appendix 7.—Report of action taken during the year ended June 30, 1893, under the provisions of the act approved March 3, 1881.

Appendix 8.—Showing the stations and duties of the officers of the Ordnance Department.

Appendix 9.—Report of the board of officers convened under act of Congress approved February 27, 1893, to test magazine rifles of American invention (7 plates).

Appendix 10.—Report of the board of officers on caliber, rifling, sights, and ammunition for the magazine rifle, model 1892.

REPORTS FROM SPRINGFIELD ARMORY.

Appendix 11.—Report of principal operations, with specifications for steam-power plant.

Appendix 12.—Specifications and plans for officers' quarters (9 plates).

Appendix 13.—Description and rules for management of Colt's revolver, caliber .38, army, model 1892 (4 plates).

REPORTS FROM FRANKFORD ARSENAL.

Appendix 14.—Tests of smokeless powders for small arms (1 plate).

Appendix 15.—Progress report on manufacture of .30-caliber ammunition (2 plates).

Appendix 16.—Laboratory investigations of powders and explosives (2 plates).

Appendix 17.—Manufacture of cannon friction-primers (1 plate).

Appendix 18.—Frankford Arsenal star gauge, model 1893 (5 plates).

Appendix 19.—Effect of small-caliber rifle projectiles upon animal tissue and bone (23 plates).

Appendix 20.—Methods and appliances for ballistic work (6 plates).

REPORTS FROM WATERVLIET ARSENAL AND ARMY GUN FACTORY.

Appendix 21.—Report of principal operations (10 plates).

Appendix 22.—Construction report on 3.6-inch mortar carriage, platform, etc. (1 plate).

Appendix 23.—Specifications for highway bridge.
Appendix 24.—Specifications for machine tools.
Appendix 25.—Specifications for electric lighting.

REPORTS FROM ROCK ISLAND ARSENAL.

Appendix 26.—Report of principal operations (5 plates).

REPORTS FROM WATERTOWN ARSENAL.

Appendix 27.—Report of principal operations (5 plates).
Appendix 28.—Barbette carriage for 8-inch B. L. rifle (14 plates).

REPORTS FROM ORDNANCE PROVING GROUND.

Appendix 29.—Report of principal operation (2 plates).
Appendix 30.—Tests of smokeless powder for cannon.

CONSTRUCTION OF ORDNANCE.

Appendix 31.—Progress report on manufacture of steel forgings, etc., at the Bethlehem Iron Works, South Bethlehem, Pa.
Appendix 32.—Progress report on manufacture of steel forgings, etc., at the Midvale Steel Works, Philadelphia, Pa.
Appendix 33.—Progress report on manufacture of mortars and mortar carriages at the Builders' Iron Foundry, Providence, R. I. (1 plate).
Appendix 34.—Progress report on the manufacture of ordnance at the West Point Foundry, Cold Spring, N. Y.

REPORTS OF BOARD FOR TESTING RIFLED CANNON, ETC.

Appendix 35.—Final report of test of 12-inch B. L. cast-iron rifle, steel half tube (1 plate).
Appendix 36.—Final report of test of Hotchkiss 3-inch mountain gun.

REPORTS OF ORDNANCE BOARD.

Appendix 37.—Report on waterproof covering for field cartridges.

MISCELLANEOUS.

Appendix 38.—Annual report of chief ordnance officer, Department of the Platte.
Appendix 39.—Frankford Arsenal 3.6-inch shrapnel (8 plates).
Appendix 40.—American Projectile Company's 3.2-inch shrapnel (8 plates).
Appendix 41.—Fuse punch for Frankford Arsenal point combination fuse (1 plate).
Appendix 42.—New positive feed for Gatling machine gun (3 plates).
Appendix 43.—The modern infantry rifle, by Capt. S. E. Blunt, Ordnance Department, U. S. Army (3 plates).

Appendix 44.—Modern gun construction and breech mechanism, by Capt. Rogers Birnie, Ordnance Department, U. S. Army (8 plates).

Appendix 45.—Disappearing gun carriages, by Capt. W. B. Gordon, Ordnance Department, U. S. Army (13 plates).

Appendix 46.—The manufacture of steel for modern guns and other ordnance purposes, by Lieut. S. E. Stuart, Ordnance Department, U. S. Army.

Appendix 47.—Rapid-fire guns, by Lieut. E. St. J. Greble, Second Artillery, U. S. Army.

Appendix 48.—Strength of iron and steel at high temperatures, by Mr. James E. Howard, Watertown Arsenal, Massachusetts (2 plates).

Appendix 49.—Recoil of small arms with charges of black and smokeless powders (8 plates).

I have the honor to be, very respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The SECRETARY OF WAR.

APPENDIX 1.

Statement of principal articles procured by fabrication at the arsenals during the fiscal year ended June 30, 1893.

CLASS I.

5 12-inch breech-loading rifles, steel.
15 10-inch breech-loading rifles, steel.
1 10-inch wire-wound gun (Woodbridge pattern).
20 5-inch breech-loading siege rifles, steel.
2 3.6-inch breech-loading rifles, steel.
1 3.6-inch breech-loading rifle, steel.
10 7-inch breech-loading howitzers, steel.
16 3.6-inch breech-loading field mortars.

CLASS II.

14 15-inch carriages and chassis.
1 8-inch carriage and chassis for breech-loading rifle.
35 8-inch carriages and chassis, hydraulic cylinders.
31 3.2-inch carriages, steel, for breech-loading rifles.
9 3.6-inch carriages, steel, for mortars.
20 metallic carriages for machine guns.
20 limbers for machine-gun carriages.
25 limbers for field carriages.
25 caissons for 3.2-inch rifles.
1 mortar wagon.
6 combined forges and battery wagons.

CLASS III.

56 breech sights for 8-inch rifles.
25 breech sights for 3.6-inch rifles.
25 breech sights for 3.2-inch rifles.
101 front sights.
264 watering buckets.
30 breech covers for 3.2-inch rifles.
3 breech covers for 12-inch mortars.
20 breech covers for Hotchkiss mountain guns.
98 bow-spring brakes for 3.2-inch carriages.
34 chocks.
16 elevating bars.
50 fuse punches.
1 gunner's gimlet.
3 gunners' reamers.

25 gunners' quadrants.
10 gun covers, Hotchkiss revolving cannon.
120 handspikes, maneuvering.
48 handspikes, rear.
32 handspikes for 3.6-inch mortar carriages.
90 sets artillery harness, 2 wheel horses (new pattern).
70 sets artillery harness, 2 lead horses (new pattern).
20 sets harness for Hotchkiss mountain guns.
200 harness sacks.
130 lanyards.
28 muzzle covers and straps.
5 pointing stakes.
48 pinch bars.
25 prolonges.
100 paulins, 12 by 15 feet.
250 paulins, 12 by 12 feet.
11 priming wires.
6 primer pouches.
1 quoin.
20 rammers and staves, 12-inch rifles.
20 rammers and staves, 10-inch rifles.
20 rammers and staves, 8-inch rifles.
20 rammers and staves, 12-inch breech-loading mortars.
2 sponges and rammers, jointed, 3.2-inch rifles.
4 sponges and rammers, short, 3.2-inch rifles.
254 sponges and rammers, 3-inch rifles.
4 sponges and rammers, 12-pounder guns.
1 sponge and rammer, 6-pounder gun.
2 sponge covers, bore, 3.2-inch rifles.
4 sponge covers, chamber, 3.2-inch rifles.
12 sponge covers, 3.2-inch rifles.
3 sight pouches.
40 shell hooks.
5 scrapers for cannon.
125 thumbstalls.
4 tompions, 15-inch guns.
7 tompions, 8-inch rifles.
35 tompions, 3-inch rifles.
109 vent covers.
11 vent punches.
11 vent pieces.
2 haversacks for implements.
1 loading-tray for 8-inch breech-loading rifle.
1 leather box and belt for Hotchkiss mountain gun.
11 sets pack outfits for Hotchkiss mountain guns.
1 set implements and tools for breech mechanism, 12-inch breech-loading mortar.

CLASS IV.

78 12-inch shot, banded.
100 12-inch solid shot (1,000 pounds).
106 10-inch shot, banded.
261 8-inch shot.
25 11-inch steel shells.
57 8-inch shell (muzzle-loading).

25 12.2-inch mortar shells.
137 12-inch mortar shells.
19 7-inch cast-iron shells for breech-loading siege howitzers.
1,624 5-inch cast-iron shells.
2,097 3.6-inch cast-iron shells.
6,278 3.2-inch cast-iron shells.
5 3.6-inch mortar shells.
31 3.6-inch shrapnel.
1,540 3.2-inch shrapnel.

CLASS V.

1,439 3.2-inch shrapnel.
200 1.65-inch cartridges for Hotchkiss mountain gun.

CLASS VI.

8 Springfield rifles, caliber .30.
6,500 Springfield cadet rifles, caliber .45.
14,261 Springfield rod-bayonet rifles, model 1888.
3 officers' swords.
50 cadet swords.
501 intrenching knives.

CLASS VII.

APPENDAGES.

17 bullet molds (4 balls).
14,090 headless shell extractors.
19,688 screw-drivers.

ARTILLERY ACCOUTERMENTS.

100 artillery knapsacks.
500 artillery saber belts and plates.

CAVALRY ACCOUTERMENTS.

3,800 cavalry cartridge belts.
2,000 cavalry canteen straps.
2,500 carbine sling swivels.
4,101 pistol holsters, caliber .45.
2,900 pistol holsters, caliber .38.
2,500 saber belts and plates.
2,000 saber knots.
1 saber belt and frog for British cavalry saber.

INFANTRY EQUIPMENTS.

19,100 bayonet scabbards.
13,864 bayonet scabbard bodies.
9,088 blanket bags.
8,599 pairs blanket-bag shoulder straps.
10,470 pairs blanket-bag coat straps.
12,500 cartridge boxes, McKeever.

9,826 cartridge belt plates.
4,500 cartridge belt plates and loops.
16,107 canteens.
7,860 canteen straps.
435 frogs, sliding.
21,653 gun slings.
10,500 haversacks.
9,600 haversack straps.
500 intrenching-knife scabbards.
10,470 waist belts.
300 waist-belt plates.
931 waist belts, noncommissioned officers'.
4,500 meat cans.
11,600 tin cups.

HORSE EQUIPMENTS.

2,562 bridles, curb, cavalry.
2,000 bridles, watering.
3,500 currycombs.
2,500 carbine boots and straps.
15 breast straps.
12 brow bands.
4,000 halters and straps.
2,000 horse covers.
10 housings for brigadier-general's saddle.
4,000 lariats.
6,000 links.
6,000 nosebags.
5,000 picket pins.
1,002 saddles, cavalry, leather covered.
1,300 saddle bags, leather.
58 saddle cloths, staff officers'.
207 saddle cloths, line officers'.
450 saddle cloths, dyed-duck.
2,053 surcingles.
1,500 pairs spurs.
1,000 pairs spur straps.

CLASS VIII.

9,399 blank cartridges, 3.2-inch rifle.
31,522 blank cartridges, 3-inch rifle.
8,346 blank cartridges, 6-pounder gun.
17,364 blank cartridges, 12-pounder gun.
2,600 blank cartridges, 12-pounder mountain howitzer.
1,031,322 rifle ball cartridges, caliber .45.
30,312 rifle ball cartridges, caliber .30.
1,004,258 carbine ball cartridges, caliber .45.
1,001,760 rifle and carbine blank cartridges, caliber .45.
404,664 revolver ball cartridges, caliber .45.
719,290 revolver ball cartridges, caliber .38.
58,338 revolver blank cartridges, caliber .45.
504,642 revolver blank cartridges, caliber .38.
1,978,504 rifle bullets, caliber .45, 500 grains.
1,502,618 carbine bullets, caliber .45, 405 grains.

16,900 rifle bullets, caliber .30, nickle jackets.
130,300 revolver bullets, caliber .45, 230 grains.
252,300 round balls, caliber .45, 140 grains.
10,500 pounds lead balls, hardened (shrapnel).
1,232 rifle dummy cartrides, caliber .30.
108,850 friction primers for cannon.
1,010 electric primers, obturator.
4,728 fuses, combination.
14 fuse-plugs, metallic, percussion.

CLASS IX.

217 blocks.
106 bell shelter tents.
100 cadet cap ornaments.
98 chocks, gun.
64 chocks, roller.
62 chocks, wheel.
1 cradle, gun.
27 cranes, loading.
3 gun-lifts.
3 garrison gins.
1 gin-fall.
3 gin-slings.
3 handcarts.
6 handspikes, gin.
50 distinguished marksmen's medals.
203 gunners' badges.
250 sharpshooters' badges.
210 masks.
210 plastrons.
210 right-hand gloves.
210 singlesticks.
210 wooden sabers.
2 platforms for siege carriages.
34 platforms for mortars.
58 rollers, long.
12 rollers, short.
10 levers, complete.
40 shifting planks.
14 skids.
5 sling chains.
1 sling cart, large.
1 shears, gun.
1 siege gin.
11 sets hoistings pulleys.
7 sets trestles for mortars.
16 way planks.
175 dies, various, for reloading tools.
25 funnels, various, for reloading tools.
10 spindles, primer extracting tools.
13,500,000 pasters.
260 signal flags.
236 streamers for rifle range.
300 shot marks and staves.
273 sets marking rods, disks, and brushes.

11 sets marking outfits.
12 targets, Brinton.
25 targets, Laidley revolving.
13 targets, artillery.
18 targets, floating.
387 targets, iron, for gallery practice.
3 targets, land.
63,425 targets, paper.
400 targets, skirmish, steel.
1 target, small arms, Babbitt pattern.
6 targets, towing.

CLASS X.

40 bolts for attaching arc of elevating gear to body of gun (8-inch converted rifle).
1 elevating band, 8-inch rifle.
1 hinge pin, 8-inch rifle.
6 hinge-pin screws, 3.2-inch rifle.
1 handle for breechblock, 8 inch rifle.
1 breech plate, bronze casting, for breech-loading rifle.
33 gas check pads.
2,060 Belleville springs.
46 bolts.
5 canvas covers for 3.2-inch ammunition chests.
1 hydraulic brake, complete, for 7-inch breech-loading howitzer carriage.
87 plates for 12-inch breech-loading mortar carriage.
1 pintle block for 7-inch breech-loading howitzer carriage.
1 pole for mortar wagon.
4 pole props for rear of pole.
1 pole for Gatling-gun carriage.
32 retraction ropes, 8-inch barbette carriage.
1 stake for mortar wagon.
705 parts of field carriages.
52 parts of seacoast carriages.
26 parts of Hotchkiss mountain gun carriages.
14 parts of limbers and caissons.
24 parts of ammunition chests.
50 artillery bridles, near-horse.
50 artillery bridles, off-horse.
6 neck-yoke pads.
36 pole pads.
3 pole props.
1 canvas boot for 3.2-inch gun.
1 saddle for Gatling-gun cart.
880 parts artillery harness, various.
600 punch pins for fuse punches.
2 rammer-heads, 3.2-inch guns, long.
314 sponges for 3-inch rifles.
10 sponges for 3.2-inch rifles, bore.
26 sponges for 3.2-inch rifles, chamber.
185 sponges for 6-pounder guns.
15 sponges for 12-pounder guns.
14 sponges for 12-pounder mountain howitzers.

1 staff for Hotchkiss mountain gun.
3 sets of adjusting screws, breech sights, Hotchkiss mountain gun.
15 copper bands, 3.2-inch shells.
150 copper bands, 12-inch shells.
1,400 base plugs.
200 fuse plugs, wood.
100 sabots.
300 tin straps for sabots.
207 stocks, complete, model 1884.
184 stocks, assembled.
1,567 stocks (wood part).
8 stocks, Springfield shotguns.
121 bayonet-clasps.
7 butt plates.
594 butt-plate screws.
4 butt-plate covers.
536 band springs.
829 barrels.
63 barrels, caliber .30.
97 breechblocks.
13 breechblock caps.
10 breechblock cap screws.
38 breech screws.
226 bands, upper.
192 bands, lower.
50 band swivel pins.
120 bridles.
125 bridle screws.
100 band stacking swivels.
5 cover-stud pins.
590 cam latches.
50 cam latch springs.
884 extractors.
4 extractors, Springfield shotguns.
300 ejector springs.
300 ejector spring spindles.
187 ejector studs.
2,000 front sights.
2,005 front sight pins.
32 front sight covers, model 1890.
20 front sight cover pins.
1,325 guards, complete.
1 guard bow.
42 guard-bow nuts.
834 guard screws.
336 hammers.
208 hinge pins.
5 firing pins, experimental rifle, caliber .30.
6,385 firing-pins.
700 firing-pin screws.
10 leaf slides.
37 locks, complete.
2 lock plates.
100 mainsprings.
936 mainspring swivels.

787 mainspring swivel rivets.
23 ramrods.
358 ramrod stops.
13 rod bayonets.
447 rod-bayonet heads.
1,710 rear sights, complete.
20 rear-sight bases.
1,279 rear-sight screws, front and rear.
10 rear-sight leaves.
20 receivers.
1,555 sears.
700 sear screws.
100 sear springs.
237 sear-spring screws.
957 side screws.
649 side-screw washers.
2,644 sight-protector bands.
296 tips.
408 tip screws.
39 triggers.
43 trigger screws.
346 tang screws.
45 thumbpieces.
2,263 tumblers.
1,316 tumbler screws.
302 tumblers, swiveled.
50 belt buckles, officers' sword-belts.
2,500 buckles, bar, brass, $\frac{3}{4}$ inch.
600 Hoffman attachments.
200 hook attachments.
20 brass hooks for canteens.
1,086 parts of blanket bags.
100 parts of McKeever cartridge boxes.
1 guidon socket.
265 bits, curb, cavalry.
458 bridle reins.
120 cincha straps.
2,500 curb straps.
20 girth straps.
9,000 halter straps.
438 headstalls for bridles.
3,050 hooks, snap.
36 parts of bridles.
9,500 parts of saddles.
60 lariat straps.
144 ovals, guard plates.
225 ornaments for bridles.
5,000 rings, brass, $1\frac{1}{4}$-inch.
5,000 rings, iron, $2\frac{1}{2}$-inch.
1 saddle cover, leather.
4,570 saddle-bag studs.
60 spring snaps.
3,918 pairs stirrup straps.
850 pairs stirrups, hooded.
325 cartridge bags, 15-inch gun.
156 cartridge bags, 12-inch breech-loading rifle.

2 cartridge bags, 11-inch muzzle-loading, converted rifle.
936 cartridge bags, 10-inch breech-loading rifle.
212 cartridge bags, 8-inch breech-loading rifle.
600 cartridge bags, 10-inch smooth-bore gun.
409 cartridge bags, 8-inch gun.
150 cartridge bags, 3.6-inch breech-loading rifle.
10,877 cartridge bags, 3.2-inch rifle.
31,140 cartridge bags, 3-inch rifle.
23,720 cartridge bags, 12-pounder gun.
2,630 cartridge bags, 6-pounder gun.
25 cartridge bags, 5-inch rifle.
500 cartridge bags, 4½-inch rifle.
50 cartridge bags, 7-inch breech-loading howitzer.
442 cartridge bags, 3-inch Hotchkiss mountain gun.
160 cartridge bags, 12-inch breech-loading mortar.
25 cartridge bags, 3.6-inch breech-loading mortar.
10,001,000 cartridge primers.
4,550 cartridge shells, caliber 30.
11,000 cartridge shells, rifle and carbine.
3 point plugs, for 3.6-inch shell.
88 point plugs, for shrapnel.
2 interiors, for shrapnel.
9,272 parts Laidley revolving targets.
4,111 parts of targets.
50,000 cloth silhouettes.
85,000 paper silhouettes.
187 silver bars for sharpshooters' badges.
2 disks for shells.
6 parts of hand sling cart.
4 parts of gin.
6 shoes for gin.
10 nave-boxes.

TOOLS AND MISCELLANEOUS.

850 arm chests.
2,291 boxes, packing.
5 crates, packing.
6 cases.
604 tin cans.
300 metallic powder kegs.
100 boxes cleaning materials.
24 anchors for artillery targets.
30 cartridge holders, wood.
2 pressure barrels, caliber .30, complete, with crusher gauge.
1 corrugated plate model, 3.2-inch rifle.
1 bed, fixtures, etc., for shop comparator.
1,300 pieces copper for Rodman pressure gauge.
1 wooden model, 3.2-inch shell.
8 sample boards, components of arms.
300 cast-brass plates for trophy guns at West Point.
52 aprons, Smith's.
226 bushings, various.
5 bushings, rifle.
68 bits, assorted.
100 quarts blacking for leather.

150 boxes ingredients for leather.
100 bottles indelible ink.
25 boxes stencil paste.
100 button sticks.
25 countersinks.
42 counter bores.
20 chisels, various.
6 coal bags.
24 clamps, saddlers'.
289 cutters, assorted.
35 chamois-skin cases, for swords.
1,000 cylinders, pressure gauge.
1,200 copper washers.
1,500 copper prisms.
6,000 copper cylinders.
608 dies, various.
779 drills.
6 drifts.
1,422 files, assorted.
281 files, rotary.
2 flatters.
6 grindstones, arbor cranks, and frames, iron, complete.
1,500 gas checks.
500 gas-check washers.
46 gauges.
1 set gauges.
25 gallons lacquer.
42 hinges, hasps, etc.
9 handcarts.
23 inspecting instruments, various.
13 parts of inspecting instruments.
2 jigs, filing.
4 ladders.
6 marline spikes.
1,224 mills, armorers'.
6 mauls.
11 mandrels.
1 measuring rod.
11 oil cans.
4 punches, assorted.
5 pressure gauge, crusher.
100 parts of army coal-heater.
143 reamers.
185 racks, arm, portable.
1 set caliper arms.
40 steel washers.
2 sets brass measuring strips.
17 sets ring gauges, projectiles.
2 sets tools, making seats pressure gauge.
1 set tools for combination fuses.
1 set tools for manufacturing gun sights.
1 set tools for manufacturing quadrants.
1 set washers, interior rest.
1 set measuring and fixed points for interior diameter from 2 to 50 inches, with wooden handles.
1 stove for Quartermaster's Department.

280 parts of stoves, various.
12 shoeing-boxes, leather.
31 sets stencil outfits.
8 stamps, seals.
9 screw-drivers.
995 parts of hand and bench reloading tools.
3,300 pounds harness oil.
675 pounds black paint.
1,305 pounds olive paint.
2,043 pounds paint.
116 pounds black wax.
95 taps, various.
36 tool bags.
3 tools for current service.
130 tools, various.
1 templet for use with ring gauge.
141 wrenches.
1 windlass for moving targets.
33 wheel grease cans.
1 wheel grease can knife.
1 bullet pressing machine.
3 grinding machines.
1 cone cover drilling machine.
1 cone cover graduating machine.
1 cone cover marking machine.
1 closing lead-pipe machine.
1 reducing lead-pipe machine.
1 sizing lead-pipe machine.
1 train winding machine.
1 screw-press.

APPENDIX 2.

Statement of principal articles procured by purchase during the year ended June 30, 1893.

CLASS I.

22 12-inch breech-loading rifled mortars.
3 8-inch breech-loading rifles.
4 Hotchkiss mountain guns, caliber 3-inch.
1 Hotchkiss light rapid-fire gun, caliber 4.72-inch.

CLASS II.

8 12-inch spring-return mortar carriages.
1 10-inch disappearing carriage.
1 Hotchkiss center-pivot carriage, caliber 4.72-inch.
4 Hotchkiss mountain gun carriages and limbers (steel), caliber 3-inch.
2 Hotchkiss revolving gun carriages and limbers, caliber 1.5 inch.
1 Raskazoff siege carriage.

CLASS III.

1 set accessories and spare parts, Hotchkiss rapid-fire gun, caliber 4.72-inch.
1 set accessories and spare parts, Hotchkiss rapid-fire gun carriage, caliber 4.72-inch.
1 set loading tools, Hotchkiss rapid-fire gun, caliber 4.72-inch.
4 sets accessories and spare parts, Hotchkiss mountain gun, caliber 3-inch.
219 accessories and spare parts, Hotchkiss revolving cannon, caliber 1.5-inch.
20 pack saddles and bridles, complete, Hotchkiss mountain gun, caliber 3-inch.
1 gunner's quadrant.
6 globe lanterns.
4 mauls.
8 scrapers for mortars.
400 spring-draft links, Mogul.

CLASSES IV AND V.

1 12-inch steel shell for breech-loading mortar.
10 7-inch Justin projectiles.

1,000 3.2-inch shrapnel.
1,000 3.2-inch steel shrapnel.
1,500 3.2-inch electrically welded shrapnel.
200 rounds 4.72-inch Hotchkiss shell, light, without powder.
150 rounds 4.72-inch Hotchkiss shell, heavy, without powder.
100 rounds 4.72-inch Hotchkiss shrapnel, heavy.
100 rounds 4.72-inch Hotchkiss canister, heavy.
500 3-inch Hotchkiss shell, percussion fuse.
500 3-inch Hotchkiss shrapnel, with combination fuse.
200 1.65-inch Hotchkiss shell, with fuse. (No powder.)
5,000 rounds ammunition for 1.65-inch Hotchkiss mountain gun.
500 rounds fixed ammunition, loaded and fused for 6-pounders Driggs-Schroeder rapid-fire gun, complete.
24 hand grenades.

CLASS VI.

1 Mannlicher rifle, caliber 6.5 millimeters.
1 Dutch magazine rifle, caliber 6.5 millimeters.
70 Spencer repeating shotguns.
4,500 Colt's army revolvers, caliber .38.

CLASS VII.

151 artillery saddle blankets.
8,277 cavalry saddle blankets.
14,983 cartridge belts.
4 knives.
4 forks.
12,094 spoons.
24 tin cups.
4 tin plates.

CLASS VIII.

50 pounds giant powder.
32,691 pounds brown prismatic powder.
97,850 pounds small-arms powder.
9,774 pounds sphero-hexagonal powder.
90,000 pounds mortar powder.
3,633 pounds smokeless powder.
1,000 pounds powder for rapid-fire guns.
600,000 rifle ball cartridges, caliber .50.
18,632 cartridge cases, experimental (foreign).
1,375,000 cartridge primers for small arms.
500,000 gun wads.
14,080 pounds shot.
1,000 feet safety fuse.
175 combination fuses.

CLASS IX.

7 single blocks.
19 double blocks.
6 triple blocks.
1 quadruple block.

6	snatch blocks.
1	tackle block.
9	top blocks ($\frac{1}{2}$ ton).
10	sheaves for blocks.
8	combination hoists (2 and 5 tons).
66	wooden rollers.
1	80-ton Gantry traveling crane.
13	hydraulic jacks.
4	range-finders.
4	sling chains.
1	capstan.
2	telephines, magnetic.
2	district registers, single-pen.
1	district register, double-pen.
25	marksmen's medals, gold.
61	marksmen's medals, silver.
90	marksmen's medals, bronze.
176	cases for marksmen's medals.

CLASS X.

22	springs for 12-inch spring-return mortar carriage.
1	spring cylinder extension, 12-inch spring-return mortar carriage.
24	screw bands, No. 144, for 3.2-inch carriage.
10	spindles for 3.2-inch guns.
3	gas-checks for 3.2-inch guns.
2	brass hydraulic unions for 8-inch carriage.
3	spirit-levels for 8-inch rifle.
1	breechblock for 3.6-inch mortar.
1	wire platform for 8-inch carriage.
7	sets platforms and steps for 15-inch carriage.
3,088	parts Springfield magazine rifle.
1,135	parts Colt's revolver, caliber .45.
6,100	appendages Colt's revolver, caliber .38
230	parts Spencer repeating shotguns.
12,081	pounds copper bands for projectiles.
250	copper bands for 3-inch projectiles.
1,487½	pounds rubber buffers.
45,953	rough gun stocks.
124	steel tubular axles.
420	artillery wheels.
160	artillery collars (steel), with pads.
100	artillery collar pads.
28	saddletrees.
80	saddle reeds.
43	pounds escutcheon pins.
73,152	escutcheon pins.
57,884	harness buckles.
4,464	halter bolts.
8,928	halter squares.
23,256	iron rings.
5,220	iron snaps.
50	iron bits.
56	forage-cap badges.
72	ornaments for horse furniture.

6,192	brass grommets.
552	yards gold lace.
1,300	silver joints and ring catches.
24	steel singletrees.
12	steel doubletrees.
3	valves for hydraulic jacks.
3	ram packings for hydraulic jacks.

CLOTH, ROPE, THREAD, ETC.

1¼	pounds absorbent cotton.
7	yards asbestos cloth.
120	yards buckram.
254	yards burlaps.
125	yards braid.
82,872	yards 1-inch cotton webbing.
55,515	yards 1½-inch cotton webbing.
25,937	yards 2-inch cotton webbing.
2,400	yards 4-inch cotton webbing.
488¾	yards carpeting.
36	yards carpet lining.
25	yards canvas.
110,754	yards cotton cloth.
121⅔	yards cloth, oiled and enameled.
2	yards cloth, rubber.
560	yards cloth, woolen.
132	yards cloth trimming.
6	yards velvetine.
75	yards canton flannel.
284¾	yards flannel.
1,885	pounds cotton batting.
16,205	pounds cotton waste.
2,249	pounds cord and twine.
933⅔	yards cord and twine.
21,675½	yards cartridge-bag material.
51,381½	yards felt.
1,500	pounds hair.
128¼	pounds marline.
201½	yards matting.
8	door mats.
139	square feet mineral wool for boilers.
150	feet mineral wool for pipes.
1,027	pounds jute.
2	pounds oakum.
17,376¼	pounds rope.
117½	pounds sewing silk.
24	spools sewing silk.
3,164	pounds thread.
360	spools thread.
60	towels.
19	yards silk ribbon.
3,030	silk wipers.
30	window shades.
652	yards window shades.
9	pounds spun yarn.
25	pounds asbestos yarn.

30 pounds woolen yarn.
462 square yards hair felting.
2 awnings.

FORAGE, ETC.

10,480 pounds barley.
24,743 pounds bran.
586 $\frac{3}{56}$ bushels corn.
30 barrels flour.
24$\frac{1}{2}$ bushels grass seed.
10,100 pounds ground feed.
166 $\frac{272}{2000}$ tons hay.
1,920 pounds corn-meal.
9,152 bushels oats.
15 barrels salt.
2,342 pounds salt.
292 $\frac{506}{2000}$ tons straw.

IRONMONGERY ETC.

1,978 pounds antimony.
23 brackets.
1,075 pounds Babbitt metal.
2 bath tubs and fixtures.
12,767 bolts, carriage, etc.
4,129 pounds bolts.
4 boilers.
319 pounds brads.
12 papers brads.
91,504 pounds beams, channel.
2,970$\frac{1}{4}$ pounds brass rods.
90,269$\frac{1}{2}$ pounds brass, cartridge.
18 brass disks.
19,581$\frac{1}{2}$ pounds brass, sheet.
2 pieces perforated sheet brass, 26 by 20 inches.
474 pounds burrs.
8,640 buttons.
10 sets blind fixtures.
7,163$\frac{3}{4}$ pounds brass and bronze castings.
2,024 pounds buckthorn fencing.
2 $\frac{542}{2240}$ tons bolts and nuts for deck plates.
25 $\frac{445}{2240}$ tons steel deck plates.
72 bucket ears.
43 caps for rollers.
29 sets casters.
1 car wheel.
6 boxes for car wheels.
1,450 pounds chain.
741$\frac{1}{2}$ feet chain.
22,895$\frac{5}{8}$ pounds copper, bar.
34,934 pounds copper, cartridge.
8$\frac{1}{2}$ pounds copper rods.
5,543 pounds copper, sheet.
476$\frac{1}{4}$ pounds copper and nickel jackets.
291 cocks, assorted.

569	couplings.
7	sets couplings.
164	door catches and fixtures.
7	sets door catches.
25	sets door knobs.
370	door knobs, etc.
1	double box for shafting.
2,879,994	eyelets.
1	pound escutcheons.
5	escutcheons.
3,360	feet electric cable.
250	pounds ferro-manganese.
646	gas-burners and fixtures.
7	grate-bars.
36	papers glaziers' points.
12	pounds glaziers' points.
14	hangers for shafts, etc.
999½	pairs hinges.
3,970	hooks, assorted.
23,979	horseshoes.
2,250	pounds horseshoe nails.
1	fire-hydrant.
1	pump flange.
1	iron socket.
1	iron ferrule.
60	hose fixtures and fittings.
4	sets hose couplings.
67,853¾	pounds iron castings.
2	iron castings for tire-upsetter.
4	iron hitching posts.
1,442	pounds hoop iron.
48	iron straps.
$368\frac{60}{2240}$	tons pig iron.
39,015	pounds sheet iron.
54	pieces sheet iron.
171,423½	pounds wrought iron, bar, etc.
36	keys and blanks.
351,733	pounds pig lead.
2,375	pounds sheet lead.
717	locks, assorted.
34	sheets mica.
58,425½	pounds nails.
7,632	saddlers' nails.
7,423¼	pounds nuts.
3,532	nuts, assorted.
1	oven for range.
963	pulleys, assorted.
15	pounds brass pipe.
11¼	pounds copper pipe.
30,236	pounds iron pipe.
3,914¼	pounds lead pipe.
7,553	pounds steel pipe.
36	feet brass pipe.
14,116¼	feet iron pipe.
8,584¼	feet lead pipe.
55	feet steel pipe.

298½ pounds pipe fittings.
3,991 pipe fittings, assorted.
64 reducers.
47,680 rivets, assorted.
3,343½ pounds rivets, assorted.
5 packages rivets.
1,771 pounds rivets and burrs.
61,250½ feet metallic rope.
2,601 gross screws.
2,913 screws, lag and thumb.
440 66/144 gross screw-eyes and pins.
163 screw-tops for powder barrels.
112 pounds sash weights.
62 sash weights.
260 pounds German silver.
4 sinks.
846 pounds solder.
9,103 pounds spikes.
103 feet steel shafting, etc.
6 pieces steel shafting.
279 pounds staples.
3,200 spring cotters.
807,608¾ pounds steel, bar, plate, etc.
46,974 pounds steel castings.
57,747 pounds steel forgings.
2 steel forgings for crane bail.
2 steel forgings (test pieces).
4,261¼ pounds sheet steel.
4 steel slings for wire rope.
6 steel plates.
11 steel disks for rifle guide-plates.
4 steel balls, antifriction.
10,894 pounds steel angles.
8,350 pounds square root steel angles.
310 steel angle joints.
21,545 pounds steel billets.
60 steel rods.
25 steel saw-plates.
38⅔ tons steel rails.
608¼ pounds tacks, assorted.
3,891,027 tacks, assorted.
25,521 pounds pig and block tin.
1,100 pounds tinfoil.
5,600 tinfoil covers for fuses.
61 boxes sheet tin.
7,768 sheets tin.
842 pounds tubing.
2,048 feet tubing.
580 washers.
1,535 pounds washers.
23 water-closets and urinals.
2 sets flush pipe connections for water-closets.
10,090½ pounds brass wire.
206 pounds barb wire.
11¾ pounds brass anvil wire.
260¼ pounds copper wire.

1,290 pounds copper-covered wire.
229 pounds copper alloy wire.
10½ pounds copper annealed wire.
13¼ pounds copper anvil wire.
7,053 pounds copper cartridge wire.
44¾ pounds copper insulated wire.
10 pounds annunciator wire.
400 feet double conductor cord.
12¾ pounds German silver wire.
11,015¾ pounds iron wire.
269 pounds galvanized iron wire.
1,134 pounds tinned iron wire.
693 pounds copper-covered iron wire.
135 pounds annealed iron wire.
6,274¾ pounds steel wire.
8 pounds magnet wire.
81 pounds tin wire.
265 feet copper wire.
4,115 feet iron wire.
192 feet galvanized iron wire.
1,650 feet seamless rubber wire.
115 feet barb wire.
10 feet fuse wire.
40 feet insulated wire.
250 feet steel wire.
84 15/100 grammes platinum wire.
78 grains platinum wire.
1 pennyweight platinum.
61½ grammes platinum foil.
25 wire screens.
1,567 pounds wire fencing.
409 window fixtures.
72 sets window fixtures.
4,125 square feet wire cloth.
1,076 square feet wire netting.
2,300 square feet wire fencing.
72 square feet copper gauze.
14,109 pounds zinc.
100 feet zinc.
3⅜ pounds titanium aluminum.

LEATHER, HIDES, ETC.

12 sides alum tanned leather.
254 sides bridle leather.
91¼ pounds belt leather.
14 pounds bridle leather.
91,102¾ pounds harness leather.
49½ pounds lace leather.
103 pounds polishing leather.
67½ pounds sole leather.
89¾ pounds walrus leather.
17,526¼ square feet bag leather.
130,576¼ square feet collar leather.
3,212 square feet enameled leather.
857½ square feet lace leather.

52	square feet maroon leather.
3,200	feet belt lacing.
14,665¼	feet leather belting.
38½	feet rubber belting.
3,658	square feet flesher skins.
265¾	square feet elk skins.
54	sheepskins.
64	lambskins.
4	buckskins.
96	rawhides.
30½	pounds bristles.
590⅝	pounds black wax.

LUMBER, ETC.

319	feet battens.
136	battens.
20	boards.
498,228½	feet boards.
14,216	feet joists.
550,155	feet plank.
355	pieces plank.
39,714½	feet scantling.
402,061	feet timber.
8,100	laths.
259,500	shingles.
8,449¾	feet strips.
54	posts.
65	piles and poles.
1,000	pickets.
1,450	railroad ties.
27½	pounds lignum vitæ.

BUILDING MATERIALS, ETC.

586½	pounds asbestos.
210	feet asbestos.
562,450	bricks.
3,273½	barrels cement.
4	bags adamantine plaster.
11½	barrels coal-tar.
611	gallons coal-tar.
10	doors.
2,939	feet drain pipe.
146	drain pipe bends, etc.
402	pounds elastic cement.
$50\frac{1025}{2240}$	tons fire-clay.
73	bushels fire-clay.
63	barrels fire-clay.
7	pieces brown stone.
141	pieces granite.
604	granite blocks.
480	bushels gravel.
10	yards gravel.
9,310	feet window glass.
1,944	lights window glass.

50 pounds plastering hair.
2 bushels plastering hair.
812 1/3 barrels lime.
428 3/4 bushels lime.
6,338 feet moldings.
9 barrels plaster of Paris.
1,018 pounds plaster of Paris.
1,510 feet tarred paper.
2,058 pounds tarred paper.
575 cubic yards building sand.
1,414 bushels sand.
1,057 cubic yards stone.
50 tons stone.
1,662 feet tiles.
49 tiles.
23,429 slates.
16 barrels distillers' returns.
120 tons fire-sand.
158 1390/2240 tons molding sand.
5,392 feet weather strips.
566 feet gutter spouts.
1 iron funnel for gutter.
2 copper heads for gutter.
36 sets window blinds.
34 pairs window blinds.
43 pairs window sash.
26 window sash.
1 wood mantle.
6 skylights.
7 window sills.
7 window caps.
18 door springs.
1 marble slab.
40 pieces sandstone.
194 perches stone.
10 perches slate stone.
316 1/6 yards wall paper.
536 rolls wall paper.
10 shoes for pipe.
310 feet top and bottom rails.
8 poplar columns.
8 purlins.
8 iron rafters.
9 iron sills.
45 pounds alabastine.
25 casks land plaster.
5 iron gates.
10 stone posts.

MATERIALS FOR HEATING, LIGHTING, CLEANING, ETC.

49 bath-bricks.
1,329 brooms, corn.
752 brushes, dusting, etc.
118 125/144 square feet card clothing.
400 3/4 pounds candles.

189 pounds concentrated lye.
67 boxes concentrated lye.
833 chamois-skins.
3,371 bushels charcoal.
63 barrels charcoal.
5,897$\frac{1253}{2240}$ tons anthracite coal.
3,817$\frac{626}{2240}$ tons bituminous coal.
1141/4 tons coke.
113 pounds corundum.
339 corundum and emery wheels.
184 reams crocus and emery cloth.
4,548 pounds crocus and emery.
20 reams emery paper.
28 grates.
6 grate fixtures.
1 register.
1 fire fender.
1,600 pounds kaolin.
9 chandeliers.
56 electric lamps
29 lamps.
261 lamp fixtures.
72 lanterns
14 lantern fixtures.
409 lampwicks.
151/4 pounds lampwick.
61 gross matches.
600 boxes matches.
97 mops and handles.
143 pounds paraffine.
354 gallons paraffine.
76 pounds pumice-stone.
3 barrels rosin.
4,072 pounds rosin.
100 pounds rotten stone.
843/4 reams sand-paper.
650 yards sand-paper.
194 cakes soap.
5,3003/4 pounds soap.
264 gallons soft soap.
30 barrels sea-coal facings, etc.
17,432 pounds sea-coal facings, etc.
546 pounds sponge.
13 stoves, various.
56 stove fixtures.
216 pounds stove polish.
22 papers stove polish.
270 feet stovepipe.
36 stovepipe elbows.
1 foot bath.
1,264 papers tripoli.
12 wash basins, bowls, etc.
3 sets washtubs, etc.
15,920 fire-bricks.
30 sets fire-brick.
2 pounds polishing paste.

100	boxes Putz pomade.
56	pounds Putz pomade.
20	cords fire-wood.
50	pounds tripoline.
707	pounds polishing compound.
15	barrels pewter sand.
36	gallons Stuart's boiler purge.

MATERIALS FOR OFFICE USE.

549	waste-baskets.
64	books of reference.
300	cards.
5	pounds stencil boards.
300	sheets stencil boards.
450	sheets card-board.
57½	pounds card-board.
25	pounds bristol board.
192	yards drawing paper.
6	boxes artists' pencils.
6	quires drawing paper.
36	bottles India ink.
2	pieces India ink.
43	pieces India rubber.
145	drawing instruments.
30¼	reams paper.
3,241	sheets paper.
74	pieces office furniture.
8	rubber stamps.
36	file clips.
20,000	seals.
21	boxes seals.
228	yards tracing cloth.
18	rolls tracing cloth.
584	thumbtacks.
122	gross pens.
48	crow-quill pens.
1,636	lead pencils.
2	boxes crayons.
6	typewriters and hektographs.
64	ribbons, etc., for typewriters and hektographs.
408	bottles ink.
523	pounds printing ink.
10	pounds hektograph composition.
15,750	envelopes.
2	clocks.
3,530	dials for watch-clock.
98	bottles mucilage.
12	mucilage stands.
1,043	pounds sealing wax.
30	pads.
411½	pounds roller composition.
6,200	tags.
224¾	pounds type.
5	fonts type.
1,000	labels.

49 boxes labels.
988 paper fasteners.
12 boxes paper fasteners.
15 papers pins.
13 gross rubber bands.
1 letter press, table, and bath.
803 various articles.

LABORATORY STORES, ETC.

90⅜ gallons acid.
17,922 pounds acid.
773½ gallons alcohol.
31 pounds alum.
47 pounds aqua ammonia.
283¾ pounds beeswax.
1,096¼ pounds borax.
12 electric batteries.
819 parts electric batteries.
807 bottles, jars, etc.
4 pounds camphor.
142 crucibles.
15,893 corks.
255½ pounds chalk.
7 pounds rubber corks.
100 pounds cream of tartar.
150 feet conductor cable.
385 pounds chloride of lime.
36 pounds chloride copper ammonia, etc.
4,773 electric supplies.
9⅜ pounds electric supplies.
110 pounds flaxseed.
15 pounds linseed meal.
361 glass tubes, etc.
½ pound black oxide of copper.
420 pounds sulphate of copper.
1 pound gelatine.
2,990½ pounds glue.
6½ gallons glue.
10 pounds stove cement.
136 gallons glycerine.
201 pounds glycerine.
33¼ pounds gum arabic.
1¼ gallons horse medicine.
50 pounds gum tragacanth.
18 bottles liniment.
47½ gallons isinglass.
10 pounds isinglass.
32 pounds iron and its preparations.
182 pounds mercury and its salts.
½ pound spirits of niter.
⅛ gallon spirits of niter.
200¼ pounds oxides, various.
1,010 pounds potash.
80 pounds potash, bichromate.
194 pounds potash, chlorate.

1 pound potash, chloride.
8 pounds potash, carbonate.
7 pounds potash, hydrate.
1 pound potash, nitrate.
2 pounds potash, oxalate.
23 pounds potash, prussiate.
1 ounce potash, bisulphate.
2 ounces potash, bromide.
2 ounces potash, cyanide.
6 ounces potash, ferrocyanide.
2 ounces potash, iodine.
2 ounces potash, meta.
4 ounces potash, permanganate.
1 ounce potash, sulphocyanide.
127½ reams paper.
119,600 pounds paper.
851 rolls paper.
1,035 yards paper.
157 pounds sal ammoniac.
2,451 pounds sal soda.
24 pounds sulphur.
2,228½ pounds tallow.
13 thermometers.
2 hydrometers.
3 sets scales and weights.
1 box weights.
1,119 photographic material.
3⅜ pounds photographic material.
2,565⅞ pounds soda and its preparations.
1,833½ pounds chemicals, various.
126½ gallons chemicals, various.
54 gallons molasses.
239 gallons vinegar.
11 pounds vasaline.
3 pounds tobacco.
1 extraction apparatus.
2,035 chemical apparatus, various.

PAINTS, OILS, ETC.

223¾ gallons drier.
10 pounds drier.
30,914⅞ gallons gasoline.
388 pounds lampblack.
275 pounds litharge.
30¼ pounds extract of logwood.
314¼ gallons benzine.
85 pounds black lead.
470 pounds red lead.
32,313 pounds white lead.
992 gallons naphtha.
17 gallons castor oil.
3 bottles castor oil.
219½ gallons cod-liver oil.
263¾ gallons neat's-foot oil.
7,667¼ gallons illuminating oil.

16,908½	gallons lubricating oil.
4	bottles clock oil.
5,408¼	gallons linseed oil.
660	pounds putty.
16¼	gallons paint.
4,421	pounds paint, in oil.
112,400¾	pounds paint, dry.
1,517½	pounds shellac.
10	gallons shellac.
2,283	gallons spirits turpentine.
10	pounds Venice turpentine.
518	gallons varnish.
12	bottles varnish.
7,102	pounds whiting.
3,570½	gallons petroleum.
596	pounds petroline.
100	pounds cosmic.
20	quarts cosmic.
8	packages gold bronze.
1½	pounds gold and bronze.
50	pounds zinc.
72	pounds hard-oil finish.
26	gallons hard-oil finish.
83	pounds hard-wood filler.
33	pounds nut-galls.
112⅓	pounds calcimine.
30	pounds anticalcimine.
1,644	pounds lubricating compound.

MISCELLANEOUS.

76	rubber disks.
67	rubber rings.
4	rubber valves.
2½	pounds rubber rods.
198	pounds rubber gaskets and rings.
17½	pounds rubber car springs.
12	rubber anti-shaft rattlers.
3¼	pounds sheet rubber.
12	packing for hopper closets.
30	rubber washers.
1	rubber coat.
3	pairs rubber boots.
36	pairs rubber overshoes.
7	pairs rubber slippers.
6	pairs rubber gloves.
4,961	feet rubber hose.
538	feet rubber tubing.
1,073¼	pounds packing, assorted.
7	horses.
2	canvas hose pipes.
2,647	pounds axle grease.
84	cans axle grease.
6	sets post harness.
267	parts post harness.
195	feet pipe covering.

4,048¾ pounds Japan wax.
11 ash barrels.
22 oil barrels.
13 whips.
528 whip stocks.
1 whip socket.
13 quarts harness dressing.
498 tin cans.
400 powder canisters, 5-pound.
200 powder canisters, 2-pound.
2 powder barrels.
1 powder keg.
804 pasteboard boxes.
524 packing boxes.
12 finger cots.
10 gallons belt dressing.
25 pounds belt dressing.
2 dumping carts.
2 1-horse wagons.
3 hand trucks.
6 railroad trucks.
1 pung.
19 wheels for trucks, etc.
13 wagon springs, etc.
1,501 railroad and bridge tickets.
2 tanks.
½ pound splicing compound.
24 electric bells.
5 loads manure.
5 cords manure.
4 tons fertilizers.
1 roll sand cloth.
11 horse blankets.
6 horse covers.
4 leather fly nets.
1 water cooler.
10,520 pounds cupola daubing.
1 set sleigh bells.
1 storm apron.
1 mirror.
1 tub.
200 graphite washers.
9 leather cases for heliographs and tripods.
12 bushel baskets.
4 grease traps.
3 nickel-plated supply pipes.
21 loads sawdust.
4 cords sawdust.
5 barrels sawdust.
8 bottles hoof dressing.
2 boxes hoof ointment.
25 pounds asbestos millboard.
10 gallons Crocket's preservative.
36¼ pounds gutta-percha.
24 hand grenade fire extinguishers.
40 iron bunks, 3 feet wide.

INSPECTING INSTRUMENTS.

5 calipers, Vernier.
3 calipers, micrometer.
13 heliographs.
1 step-gauge, complete.
2 magnifying glasses.

MACHINES, ETC.

6 iron ladles.
4 gas meters.
1 250 horse-power duplex Corliss steam engine.
1 20-25 horse-power automatic steam engine, complete.
1 Universal spindle milling machine.
1 vertical spindle milling machine.
1 Universal milling machine, No. 3, complete.
1 power milling machine, No. 0.
2 heavy Universal milling machines.
1 heavy vertical milling machine.
4 hand milling machines.
2 milling machines.
1 30-inch upright drill, complete.
1 36-inch upright drill, complete.
1 50-inch upright drill, complete.
1 cartridge primer anvil press.
1 cartridge primer loading press.
1 cartridge primer hand press.
1 4-spindle gang drill, No. 4, complete.
1 upright drill complete.
10 drilling machines for barrels.
1 72-inch Universal radial drilling machine.
1 Stiles power punching machine.
1 12-inch cylinder boring machine.
1 slotting machine, 13-inch stroke, complete.
1 26-inch slotter.
1 Sturtevant blower, No. 8, adjustable bed.
1 Sturtevant blower, No. 9, adjustable bed.
1 mortice and borer machine, complete, with chisels and bits.
1 Universal trimmer, No. 2, with knives.
1 Stow drill-press, No. 6, screw-feed.
1 automatic tool-grinder, complete.
1 D grinding machine, No. 4.
2 drill-grinding machines, complete.
1 edge jointer and molder.
1 20-inch buzz planer.
1 traverse planer, 27 inches by 25 feet.
1 traverse planer, 15 inches by 6 feet.
1 20-inch surface planing machine.
1 double surface planer.
1 14-inch pillar shaper.
1 pillar-shaping machine.
2 19-inch shapers.
1 pillar-shaping machine, 15-inch stroke, complete.

6 patent gear cutters.
7 gear cutters.
1 gear-cutting attachment.
2 40-inch band saws.
1 36-inch rip-saw bench.
1 automatic sewing machine.
1 saw table, complete.
1 Berry and Orton band saw, No. 1, complete.
1 self-feed, vertical cut-off saw.
1 sand-papering machine.
1 steel precision screw.
5 engine lathes.
6 engine lathes, 4-foot bed, complete.
3 engine lathes, 16-inch, 6-foot bed.
4 engine lathes, 16-inch, 7-foot bed.
1 wood-turning lathe, 25 by 11 inches.
1 Rivett lathe, No. 4, with rests, etc, complete.
4 turning and boring lathes.
6 turning and finishing lathes.
1 36-inch metal-working lathe.
2 pattern-maker's lathes.
1 large face-plate lathe.
1 small face-plate lathe.
1 turret lathe, 17-inch swing.
5 Singer sewing machines, No. 3.
1 geared ladle, 4,500 pounds capacity.
1 geared ladle, 2,000 pounds capacity.
1 Harrington screw hoist, 2,000 pounds.
1 gas machine, 500 lights.
1 mowing machine.
5 lawn mowers.
1 2-horse Buckeye mower.
1 harrow.
2 cultivators,
1 steam fire-engine, complete.
2 spindle centering machines, complete.
1 cutter and reamer grinder, complete.
1 exhaust fan, No. 8.
1 Pratt's patent power shears, No. 2.
1 Gould pressure pump, No. 3, complete.
1 4-inch measuring machines, complete.
1 screw machine, No. 6.
1 6-inch centrifugal steam separator.
2 upright pump-boring machines.
1 Universal post-boring machine.
1 Universal horizontal boring machine
1 Sawyer's magnetic metal separator.
1 No. 5, 35-inch pressure for blower.
1 20-inch horizontal hydraulic drawing press and duplex pump.
1 rifling machine.
1 Lancaster grapple.
1 80-pound trip hammer, No. 3, B, complete.
432 parts of machines.
389 parts of agricultural machines.

TOOLS, ETC.

78	awls.
101	axes.
10	augers.
5	braces.
156	bits.
255	buckets, water.
2,896	brushes, paint, etc.
9	chisels.
5,312	pounds chalk lines.
146	chalk lines.
29	coal-hods.
535	carpenters' tools, various.
1,248	drills.
3	sets drills.
34	dies.
11,767	files.
2	sets valve files.
40	forks, hay and manure.
4	gauges.
1,285	pounds grindstones.
1	grindstone, complete.
14	hatchets and hammers.
2,182	handles, assorted.
33	hoes, garden, etc.
308	knives, assorted.
156	spirit levels.
37	mallets.
108	machinists' tools, various.
14	sets machinists' tools, various.
36	nippers.
1	nail puller.
434	oil cups and oilers.
21	oilstones and slips.
78	picks.
15	punches, assorted.
4	pumps.
107	rakes, hay, etc.
921	rasps.
16	rules.
11	riddles.
331	spades and shovels.
652	saws.
370	saw blades.
89	scythes, etc.
200	scythestones.
58	scythe snaths.
241	stamps, letters, and figures.
9	sets stamps, letters, and figures.
24	scales and weights.
6	steel dies.
360	stencils.
69	saddlers' tools, various.
2	smiths' tools, various.
5	squares.

12 tape lines.
157 wrenches.
48 wheelbarrows.
10 pairs shears.
19 tinners' tools, various.
1,913 tools, various.
106 utensils, various.
104 vises.
4 sets stocks and dies.
1 set cutters for letters.
1 set clamps.
14 sets taps.

APPENDIX 3.

Statement of ordnance, ordnance stores, etc., issued to the Military Establishment, including the national homes for soldiers of the volunteer and regular Army and exclusive of the militia, during the fiscal year ended June 30, 1893.

CLASS I.

3 Gatling guns, 10 long barrels, caliber .45.
5 1.5-inch Hotchkiss revolving cannon.
5 1.65-inch Hotchkiss mountain guns.
7 3-inch rifled guns.
20 3.2-inch breech-loading rifles.
4 6-pounder guns.
1 Driggs-Schroeder 6-pounder breech-loading rifle.
1 Hotchkiss 6-pounder breech-loading rifle.
1 Seabury 6-pounder breech-loading rifle.
2 heavy 12-pounder guns.
2 light 12-pounder guns.
1 5-inch breech-loading siege cannon.
1 8-inch breech-loading steel cannon.
1 8-inch converted rifle.
1 10-inch smooth-bore gun.
1 12-inch cast-iron, steel-hooped mortar.

CLASS II.

1 Gatling-gun carriage without limber.
2 Gatling-gun carriages and limbers.
1 metallic carriage for machine guns with mount for Gatling gun.
5 1.5-inch Hotchkiss-gun carriages and limbers.
4 1.5-inch Hotchkiss-gun ammunition wagons.
6 1.65-inch Hotchkiss mountain-gun carriages.
9 3.2-inch rifled gun carriages without limbers.
1 3.6-inch gun carriage without limber.
4 4.5-inch gun carriages without limbers.
1 5-inch steel-gun carriage without limber.
2 6-pounder gun carriages without limbers.
1 free-recoil barbette carriage.
2 8-inch breech-loading rifle carriages.
13 8-inch barbette carriages and chassis.
4 8-inch casemate carriages and chassis.
1 8-inch howitzer carriage and limber.
1 12-inch mortar carriage, Canét (French).
14 15-inch barbette carriages and chassis.

1 6-pounder gun caisson.
1 6-pounder Driggs-Schroeder, crinoline mount.
1 6-pounder Hotchkiss crinoline mount.
1 6-pounder Seabury crinoline mount.
1 limber for machine-gun carriage.
1 limber for 3-inch gun carriage.
2 limbers for 3.2-inch gun carriage.
6 portable forges.
6 portable forge chests.
1 mortar wagon.

CLASS III.

4 sets accessories, Hotchkiss revolving cannon.
4 sets accessories, Hotchkiss ammunition wagon.
1 front sight, Hotchkiss revolving cannon.
2 gun covers, Hotchkiss revolving cannon.

IMPLEMENTS FOR HOTCHKISS MOUNTAIN GUN.

1 boring bit.
7 breech covers.
5 breech sights.
4 bricoles.
11 cleaning brushes.
5 dismounting pins.
5 extractors.
1 grease box.
7 gunners' haversacks.
9 lanyards.
7 muzzle covers.
7 oil cans.
15 packing outfits, complete.
1 pincers.
5 pliers, cutting.
3 primer pouches.
5 priming wires.
1 punch.
60 feet rope.
1 saddler's knife.
7 screw-drivers.
2 sponges, bristle.
6 sponges and staves.
5 stop bolts.
1 fuse wrench.

APPENDAGES FOR GATLING GUN, CALIBER .45.

2 cam extractors.
4 drifts.
10 feed guides.
7 gun covers, long.
1 gun cover, short.
2 hoppers.
1 oiler.
2 pointing levers.

1 riveting hammer.
4 lock screw-drivers.
4 small screw-drivers.
4 T-screw-drivers.
2 shell drivers.
2 shell extractors
4 wiping rods.
2 cascabel wrenches.
2 lever axis pin wrenches.
4 pin wrenches.
2 rear guide nut wrenches.
1 screw-wrench.

IMPLEMENTS FOR 3.2-INCH RIFLE.

9 breech covers.
21 breech sights, bronze.
3 breech-sight pouches.
8 breech straps.
3 cold chisels, 8 inches long.
5 files.
16 front sights, bronze.
5 front-sight covers.
1 gunner's gimlet.
5 gunners' haversacks.
1 gunner's pincers.
1 gunner's reamer.
1 hammer.
4 handspikes.
1 knapsack boot.
7 lanyards.
4 muzzle covers and tompions combined.
7 oilers, brass.
16 paulins, 12 by 12 feet.
22 primer pouches.
3 priming wires.
5 prolonges-sections picket rope.
2 punches, steel.
6 shovels.
11 sponge covers, bore.
14 sponge covers, chamber.
6 sponges and rammers with staves bore.
6 sponges and rammers, short chamber.
3 tool boxes.
6 vent punches.
10 wheel-grease cans.
8 wheel-grease can knives.
2 nut wrenches.
3 screw wrenches.

ARTILLERY IMPLEMENTS AND EQUIPMENTS.

1 basket for mortar implements.
3 breech covers, 12-inch mortars.
10 breech sights, 8-inch guns.
1 breech-sight seat, 8-inch gun.

125 buckets, canvas.
5 buckets, iron.
22 budge barrels.
2 elevating bars, 8-inch mortars.
4 elevating bars, 10-inch mortars.
6 elevating bars, 10-inch guns.
16 elevating bars, 15-inch guns.
1 front sight, 6-pounder Hotchkiss gun.
1 front sight, 8-inch rifle.
32 fuse punches.
4 gun lifts, 15-inch Rodman.
2 gunners' gimlets, field.
20 gunners' haversacks.
2 gunners' levels.
44 gunners' sleeves.
4 handspikes, counterpoise.
119 handspikes, maneuvering.
25 handspikes, rear.
22 handspikes, shod.
2 handspikes, trail.
32 handspikes, truck, iron.
65 harness bags.
4 sets harness, Hotchkiss mountain guns.
18 sets harness, 2 lead horses.
20 sets harness, 2 wheel horses.
1 set harness, cavalry forge.
1 ladle and staff.
7 lanterns, magazine.
38 lanyards for friction primers.
9 muzzle covers, 8-inch rifles.
8 pass boxes.
4 paulins, 12 by 15 feet.
22 pinch bars, 8-inch barbette carriage.
4 pinch bars, 8-inch casemate carriage.
17 pinch bars, 15-inch carriage.
20 pointing cords.
5 pointing stakes.
18 priming wires.
1 quadrant.
1 quoin.
4 rammers and staves, 8-inch guns.
1 rammer and staff, 10-inch guns.
2 rammers and staves, 15-inch guns.
13 scrapers for guns.
6 scrapers for mortars.
4 shot-carrying bars.
17 shot hooks.
3 sight pouches.
2 sponge covers, 3-inch gun.
12 sponge covers, 6-pounder guns.
12 sponge covers, 12-pounder guns.
35 sponges and rammers, 3-inch guns.
3 sponges and rammers, 6-pounder guns.
9 sponges and rammers, 12-pounder guns.
1 sponge and staff, 5-inch rifle, bore.
1 sponge and staff, 5-inch rifle, chamber.

1 sponge and staff, 7-inch howitzer.
1 sponge and staff, 8-inch rifle, bore.
1 sponge and staff, 8-inch rifle, chamber.
4 sponges and staves, 8-inch guns.
1 sponge and staff, 10-inch gun.
2 sponges and staves, 15-inch guns.
1 telescope sight, Zalinski's.
8 thumbstalls.
8 tompions, 3-inch guns.
4 tompions, 12-pounder guns.
4 tompions, 4.5-inch guns.
11 tompions, 8-inch guns.
22 tompions, 10-inch guns.
3 tompions and muzzle covers, 12-inch mortars.
14 tompions, 15-inch guns.
20 tube pouches.
82 vent covers, field guns.
10 vent covers, siege guns.
36 vent pieces, field guns.
3 water tubs.
1 worm and staff, field guns.

CLASSES IV AND V.

SHOT.

100 3-inch rifle.
275 8-inch cored.
414 8-inch converted rifle.
1 10-inch breech-loading rifle.
106 10-inch smooth-bore gun.
1 12-inch breech-loading rifle.
230 15-inch smooth-bore gun.

SHELL.

1,000 1.5-inch Hotchkiss.
1,000 1.65-inch Hotchkiss.
3 6-pounder gun.
502 3.2-inch breech-loading rifle.
3 3.6-inch breech-loading rifle.
1 5-inch rifle.
1 7-inch howitzer.
171 8-inch rifle.
253 8-inch mortar.
50 10-inch gun.
44 10-inch mortar.
103 12-inch mortar.
100 15-inch gun.

SHRAPNEL.

1 3-inch rifle.
829 3.2 inch rifle.
1 self-registering steel projectile.
12 steel cartridges, with wet-proof cases, 3.2-inch.

CLASS VI.

1,433 Springfield carbines.
1,853 Springfield rifles.
814 Springfield rifles, rod bayonets.
2 Springfield rifled muskets, caliber .58.
72 Springfield shotguns.
66 Spencer repeating shotguns.
4,307 Colt's revolvers, caliber .38.
651 Colt's revolvers, caliber .45.
3 Schofield-Smith & Wesson revolvers.
24 artillery sabers.
4 artillery officers' sabers.
652 light cavalry sabers (American).
25 cavalry sabers (foreign).
1 officer's saber.
12 cadets' swords.
32 musicians' swords.
56 noncommissioned officers' swords.
38 hospital-corps knives.
321 intrenching knives.

CLASS VII.

APPENDAGES.

75 brush-wipers.
10 cleaning rods, Springfield shotgun.
66 cleaning rods, Spencer repeating shotgun.
1,367 headless shell extractors.
1,201 screw-drivers, carbine and rifle.
4,307 screw-drivers, Colt's revolver, caliber .38.
51 screw-drivers, Colt's revolver, caliber .45.
1 screw-driver, Schofield-Smith & Wesson revolver.
66 screw-drivers, Spencer repeating shotgun.
10 spring vises.
44 tumbler punches.
992 wiping rods, carbine.
3,395 wiping rods, rifle.
115 wiping rods, revolver.

ARTILLERY EQUIPMENTS.

7 knapsacks.
162 saber belts.
55 saber-belt plates.

CAVALRY EQUIPMENTS.

815 canteen straps.
1,206 carbine slings.
1,929 carbine-sling swivels.
1,348 cartridge belts.
101 pistol cartridge boxes.
4,310 pistol holsters (caliber .38).
896 pistol holsters (caliber .45).

4 pistol holsters (Schofield-Smith & Wesson).
1,038 saber attachments.
1,488 saber belts.
975 saber-belt plates.
1,321 saber knots.

INFANTRY EQUIPMENTS.

1,093 bayonet scabbards, steel, Hoffman attachment.
1,704 bayonet scabbards, steel, hook attachment.
690 blanket bags.
1,565 blanket-bag coat straps.
1,004 blanket-bag shoulder straps.
5,235 canteens.
4,935 canteen straps.
1,787 cartridge belts.
449 cartridge-belt plates.
2,425 cartridge boxes.
110 cartridge boxes, shotgun ammunition.
3,212 clothing bags.
3,004 clothing-bag straps.
118 sliding frogs.
3,604 gun slings.
4,765 haversacks.
4,327 haversack straps.
3,970 knives.
3,590 forks.
3,717 spoons.
4,215 meat cans.
35 scabbards, hospital corps knife.
625 scabbards, intrenching knife.
4,748 tin cups.
3,928 waist belts.
1,082 waist-belt plates.
117 waist belts, noncommissioned officers'.
108 waist-belt plates, noncommissioned officers'.
50 yokes for blanket-roll supports.

HORSE EQUIPMENTS.

1,216 curb bridles.
826 watering bridles.
759 carbine boots and straps.
3,032 currycombs.
279 girths, hair (cinchas).
1 girth, linen.
2,817 halters.
4,455 halter straps.
3,373 horse brushes.
714 horse covers.
2,100 lariats.
833 links.
2,505 nosebags.
613 picket pins.
638 saddles.
1,157 saddlebags, leather.

114 saddle blankets, artillery.
3,742 saddle blankets, cavalry.
18 saddlecloths, dyed duck.
20 saddlecloths, hair.
6 saddlecloths, line officers'.
199 side lines.
2,333 spurs.
3,498 spur straps.
16 stirrups with guidon sockets.
1,921 stirrups.
1,593 stirrup straps.
43 surcingles, artillery.
1,746 surcingles, cavalry.

CLASS VIII.

SMALL-ARMS AMMUNITION.

409,408 carbine ball cartridges.
1,068,134 rifle ball cartridges.
657,565 rifle and carbine blank cartridges.
283,880 revolver ball cartridges, caliber .38.
357,265 revolver ball cartridges, caliber .45.
274,300 revolver blank cartridges, caliber .38.
336,045 revolver blank cartridges, caliber .45.
1,678,990 carbine bullets.
2,909,800 rifle bullets.
498,750 revolver bullets.
107,000 round balls.
130 pounds buckshot.
9,334 pounds shot.
55,632 pounds small-arms powder.
5,810,110 cartridge primers.
5,000 cartridge shells, rifle.
9,743 cartridge shells, shotgun.
261,750 wads, shotgun.

AMMUNITION FOR CANNON.

Blank cartridges.

540 ½-pound charge, 12-pounder mountain howitzer.
27,584 1-pound charge, 3-inch rifle.
7,278 1-pound charge, 6-pounder gun.
19,713 1¾-pounds charge, 12-pounder gun.
649 2¾-pounds charge, 3.2-inch rifle.
8,585 3¾-pounds charge, 3.2-inch rifle.
1,000 12-pounder field howitzer.

Fuses.

425 base.
5 combination.
100 concussion.
405 paper.
14 percussion.
500 wood.
1 time.

Powder.

26,100 pounds cannon.
2,300 pounds field gun, I. K.
19,600 pounds hexagonal.
37,500 pounds mammoth.
200 pounds mealed.
7,500 pounds mortar.
35,360 pounds sphero-hexagonal.

Primers.

2,186 electric.
91,691 friction.
2 percussion.
2 vent sealing.
2 pounds quick match.

CLASS IX.

16 arm-racks, carbines and revolvers.
24 arm-racks, rifles and revolvers.
5 arm-racks, rifles.
378 blocks, assorted.
10 blocks, iron, assorted.
93 blocks, wood, assorted.
1 set blocks, gin.
4 blocks, tackle.
2 capstans.
5 capstan bars.
57 chocks, gun.
25 chocks, medium.
64 chocks, roller.
76 chocks, wheel.
2 chronographs.
1 chronograph chest.
1 chronograph tripod.
2 cradles.
27 cranes, loading.
3 district registers.
8 fencing bayonets.
2 fencing masks.
2 fencing muskets.
3 gins, garrison.
1 gin, siege.
1 gin fall.
2 gin keys.
6 gin shoes.
3 gin slings.
2 gin-stay chains.
200 gloves.
22 gunners' badges.
3 gun lifts.
2 gun-lift shears.
9 handcarts.
6 handspikes, gin.
5 hydraulic jacks, 15-tons.

1 hydraulic jack, 20-tons.
7 hydraulic jacks, 30-tons.
2 levers with adjustable fulcrums.
13 marking outfits.
59 ounces marking-outfit ink.
1 marking-outfit ink pad.
50 marksmen's badges.
700 marksmen's buttons.
150 marksmen's pins.
200 masks.
220 platforms.
18 sets differential pulleys.
12 sets hoisting pulleys.
140 assorted rollers.
200 wooden sabers.
125 sharpshooters' badges.
174 silver bars for sharpshooters' badges.
40 shifting planks.
152 single sticks.
22 skids.
2 sling carts.
5 sling chains.
4 sling-cart bolts.
1 sling-cart handle.
1 sling-cart pole.
31 stencil outfits.
6 boxes stencil paste.
5 stencil plates.
7 sets mortar trestles.
3 stove trucks.
2 trunnion rings.
1 velocimeter.
1 steel velocimeter ribband.
20 way planks.

TARGETS AND TARGET MATERIAL.

58 halliards with screw eyes.
2 marking rods, disks, and brushes.
30 marking staves and disks.
53 shot marks and staves.
220 signal flags.
162 streamers.
3 targets, Babbitt's, Texas.
26 targets, Brinton.
33 targets, floating, artillery.
21 targets, iron, gallery practice.
168 targets, Laidley.
14 targets, land.
32,564 targets, paper.
8 targets, towing.

PARTS OF TARGETS.

90 axles.
21 axle bolts.
20 axle-bolt caps.

24	axle washers.
930	centers.
6	centers, revolving.
44	clamps for sash cord.
18	covers.
98	cross pieces.
516	frames, Brinton.
36	frames, Cushing.
576	frames, interior.
469	frames, Laidley.
90	frames, steel.
100	frames, temporary.
110	frames, Texas.
14	frame-sustaining rods.
86	journal boxes.
1,050	journal-box pins.
4	journal posts.
24	levers.
79	lever blocks.
10	lock blocks.
12	lock bolts.
12	lock-bolt plates.
167	nave boxes.
11,395,000	pasters.
2	pulleys and fittings.
199	rails.
36	rollers, iron.
23,708	silhouettes, cloth.
98,632	silhouettes, paper.
24	sills.
26	sill stakes.
12	spring loops.
8,500	strings.
6	thumbscrews.
6	top pieces.
400	feet track.
116	uprights.
1	windlass.
833	wooden pins.
732	wooden wedges.

HAND RELOADING TOOLS.

27	brush wipers.
36	powder and shot chargers.
1	resizing die.
31	drifts.
29	funnels.
1	resizing gauge.
8	oil cans.
31	priming tools.
38	priming-tool pins.
1	shell scraper.

BENCH RELOADING TOOLS.

8	sets bench reloading tools.

SHELL-RESIZING TOOLS AND PARTS.

5 shell-resizing tools.
5 cartridge-head adjusting screws.
7 cartridge-head adjusting screw nuts.
4 cross-head pins.
4 disk screws.
104 dies, lower.
607 dies, upper, rifle.
117 dies, upper, revolver.
2 guide rods.
6 guide-rod nuts.
1 link.
6 link pins.
2 levers.
8 lever pins.
6 rings.
24 spindles.
13 spindle screws.
13 spindle-screw nuts.
4 stands.
1 die wrench.

ASSEMBLING AND CRIMPING TOOLS AND PARTS.

4 assembling and crimping tools.
2 check levers.
2 check-lever screws.
8 check-lever springs.
8 check-lever spring screws.
53 dies.
2 die holders.
4 die-holder guides.
4 die-holder guide screws.
2 die-holder set screws.
2 die-holder stop screws.
1 die lever.
5 die-lever pins.
10 shell rests.
10 shell-rest holder plates.
20 shell-rest holder-plate screws.
2 shell-rest set screws.
10 stems, carbine and rifle.
10 stems, revolver.
2 stem levers.
4 stem-lever pins.
4 stem-lever screws.
6 stem screws and dies.

POWDER-CHARGING TOOLS AND PARTS.

2 powder-charging tools.
7 chargers and dies.
4 charger slides and screws.

3 receivers and funnels.
4 receiver nuts.
7 wrenches.

PRIMER-EXTRACTING TOOLS AND PARTS.

8 primer-extracting tools.
2 cartridge-holder plates.
5 cartridge-holder plate screws.
3 levers.
5 lever pins.
621 primer extractor pins.
29 spindles.
38 spindle screws.

PRIMER-INSERTING TOOLS AND PARTS.

3 primer-inserting tools.
21 bushings, carbine and rifle.
16 bushings, revolver.
12 bushing screws.
1 pinion lever.
3 pinion-lever pins.
16 primer setters.

AUXILIARY TOOLS.

1 total-length gauge.
15 pin ejectors.
4 screw-drivers.
1 monkey wrench.
2 pin wrenches.

TOOLS FOR GALLERY PRACTICE.

19 ball molds.
12 ball-mold screws.
10 ladles, melting.
7 ladles, pouring.
3 strainers.

CLASS X.

PARTS OF CLASS I.

Parts Gatling gun.

1 axis pin, washer, and nut.
1 binding box, plate, screw, pin, washer, and key.
1 crank handle and pin.
1 pointing lever.

Parts Hotchkiss mountain gun.

3 adjusting screws.

Parts of 3.2-inch breech-loading rifle.

6 breech strap rings for lazy tongs.
18 hinge-pin securing screws.

Parts of 5-inch siege gun.

1 pintle plate.
1 recoil cylinder.

PARTS OF CLASS II.

Parts of gun carriages.

1 pole for Gatling gun carriage.
2 ammunition boxes, Hotchkiss mountain guns.

Parts of 3.2-inch rifle carriage.

17 bow spring brakes.
36 caisson bodies.
4 hooks and springs for securing spare pole.
106 linchpins.
150 linch washers.
10 neck yokes.
12 neck-yoke pads.
14 nuts, nose band, and wheel.
3 poles, carriage.
11 poles, limber.
14 pole props.
8 pole-prop hook springs.
8 pole-prop springs.
2 screw lids, bronze.
2 singletrees.
5 spring jaws for securing handspike.
106 washers.
2 wheels.

Parts of ammunition chests.

8 sets fittings.
4 keys, chains, and eye rivets.
5 keys and stay pins.
6 lid props.
1 stay pin and chain.
13 turn-buckles.

Parts of forge and battery wagon.

9 frames for forge or battery wagon.

Parts of 12-pounder carriage.

1 wheel for light 12-pounder gun.

Parts of 7-inch howitzer carriage.

1 hydraulic brake.
1 pintle block.
2 piston rods.

Parts of 8-inch carriage.

1 hand-wheel stud.
10 rear eccentric pins.
29 retraction ropes.
1 traversing circle.

Parts of 10-inch carriage.

1 piston rod.

Parts of 12-inch mortar carriage.

2,068 Belleville springs.
1 bottom plate.
1 rear cylinder head, bronze.
30 screw bolts.
1 strengthening plate.

Parts of 12-inch Krupp carriage.

1 hydraulic cylinder with piston.

Parts of 15-inch carriage.

16 bolts.
4 buffers, rubber.
22 levers.
4 obturator bars and taps.
1 piston rod.
10 rear eccentric pins.
14 retraction ropes, steel wire.

Parts of mortar wagon.

1 pole.
1 stake.

PARTS OF CLASS III.

2 brass-plated bits.
10 breast straps.
4 breechings.
139 brass-plated buckles.
51 iron roller buckles.
1 cargo cincha for pack saddle.
160 steel collars with pads.
1 gun pad for pack saddle.
20 halter chains for artillery.
12 breast-strap hooks.

12 breeching hooks.
36 collar-strap hooks.
12 lead-rein rollers.
28 martingales.
16 martingales with cincha straps.
2 neck-yoke pads, leather.
6 neck-yoke pads, rubber.
1 pack saddle, ammunition.
1 pack saddle, carriage.
100 pads, assorted.
384 pins for fuze punches.
27 pole pads, leather.
1 pair pole straps.
3 rammer heads.
48 iron rings, japanned.
1 saddle for Gatling gun cart harness.
10 sponge heads, 3-inch.
18 sponge heads, 12-pounder.
3 sponge heads, 15-inch.
35 sponges, woolen, 6-pounder.
64 sponges, woolen, 12-pounder.
2 sponges, woolen, 12-pounder howitzer.
12 sponges, woolen, mountain howitzer.
108 sponges, woolen, 3-inch.
12 sponges, woolen, 3.2-inch, bore.
24 sponges, woolen, 3.2-inch, chamber.
12 sponges, woolen, 8-inch.
1 sponge staff, Hotchkiss mountain gun.
2 sponge staves, 12-pounder.
48 springs and screws for locking collar.
6 brass stirrups.
50 stirrup leather hooks.
12 staples for saddle.
4 traces, lead.
4 traces, wheel.
101 whips.
16 whip hooks.

PARTS OF CLASS V.

300 fuse plugs, 15-inch shell.
250 sabots, 15-inch shell.
450 tin straps, 15-inch shell.
2 interiors of shrapnel.

PARTS OF CLASS VI.

Parts of Springfield carbine.

26 bands.
45 band springs.
33 bridles.
17 bridle screws.
2 butt plates.
6 butt-plate covers.
7 butt-plate cover stud pins.

2 butt-plate cover friction springs.
22 butt-plate screws.
22 cam-latch springs.
171 ejector springs.
159 ejector-spring spindles.
32 ejector studs.
166 extractors.
323 firing pins.
116 firing-pin screws.
818 front sights.
243 front-sight covers.
20 front-sight cover pins.
138 front-sight cover screws.
375 front-sight pins.
6 guard bows.
15 guard-bow nuts.
5 guard plates.
4 guard-plate screws.
67 guard screws.
1,001 jointed ramrods.
731 rear sights.
1,024 rear-sight protector bands.
158 stocks, assembled.
814 stocks, wood part.
45 swivel bars.
57 swivel-bar rings.

Parts of Springfield rifle.

96 bands, lower.
239 bands, upper.
84 band springs.
270 bayonets.
39 bayonet clasps.
149 bayonet-clasp screws.
2 breechblock caps.
268 breechblock cap screws.
382 bridles.
419 bridle screws.
29 butt plates.
191 butt-plate screws.
655 cam latch springs.
1,199 ejector springs.
1,075 ejector-spring spindles.
289 ejector studs.
1,890 extractors.
3,287 firing pins.
896 firing-pin screws.
440 front sights.
335 front-sight covers.
127 front-sight cover screws.
516 front-sight pins.
71 guard bows.
165 guard-bow nuts.
104 guard-bow swivels.
166 guard-bow swivel screws.

48 guard plates.
32 guard screws.
292 hammers.
478 hinge pins.
5 hinge-pin studs.
6 locks.
110 lock plates.
517 mainsprings.
474 mainspring swivels.
395 mainspring-swivel rivets.
18 pistol grips.
106 pistol-grip screws.
88 ramrods.
175 ramrod stops.
670 rear sights.
289 rear-sight screws, front.
337 rear-sight screws, rear.
14 rod bayonets.
37 rod-bayonet heads.
612 sears.
503 sear screws.
886 sear springs.
501 sear-spring screws.
493 side screws.
174 side-screw washers.
22 stocks, complete.
917 stocks, wood part.
18 stocks, wood part, rod bayonet.
522 tang screws.
15 thumb pieces.
101 tips.
137 tip screws.
99 triggers.
163 trigger screws.
782 tumblers.
810 tumbler screws.

Parts of Springfield shotgun.

16 extractors.
8 stocks, wood part.

Parts of Spencer repeating shotgun.

10 cartridge stop screws.
10 cartridge stop springs.
10 extractors and pins.
10 firing pins.
10 magazine springs.
10 mainsprings.
10 sear springs.
10 side-plate screws.

Parts of Colt's revolver, caliber .45.

4 barrels.
4 back straps.

141 back-strap screws.
217 bolts.
189 bolt screws.
141 center pins.
60 center-pin bushings.
172 center-pin screws.
30 cylinders.
149 ejector heads.
113 ejector rods.
168 ejector springs.
70 ejector tubes.
150 ejector-tube screws.
12 firing pins.
22 firing-pin rivets.
2 frames.
10 front sights.
48 gates.
38 gate catches.
76 gate-catch screws.
96 gate springs.
20 guards.
142 guard screws, long.
166 guard screws, short.
291 hammers.
58 hammer cams.
6 hammer rolls.
6 hammer-roll rivets.
176 hammer screws.
334 hands.
261 hand springs.
161 mainsprings.
106 mainspring screws.
370 sear and stop-bolt springs.
213 sear and stop-bolt spring screws.
57 stocks.
256 triggers.
112 trigger screws.

Parts of Colt's revolver, caliber .38.

67 crane locks.
67 crane-lock screws.
199 cylinder bolts and springs.
199 ejector springs.
67 ejector-rod heads.
199 hammers.
199 hammer stirrups.
199 hammer-stirrup pins.
199 hammer struts.
199 hammer-strut pins.
199 hammer-strut springs.
199 hands and springs.
67 latch pins.
67 latch springs.
199 mainsprings.
67 rebound levers.

199 rebound springs.
199 side plate screws.
199 stock screws.
199 triggers.

Parts of Schofield-Smith and Wesson revolver.

1 hammer.

Parts of light cavalry saber.

26 scabbards.

Parts of musicians' sword.

3 scabbards.

PARTS OF CLASS VII.

30 back straps, front.
30 back straps, rear.
682 bits, curb.
6 breast straps.
94 bridle headstalls.
180 bridle ornaments.
102 bridle reins.
50 bridle snap-hooks.
5 brow bands.
6,942 brass-bar buckles.
4,558 brass-wire buckles.
2,004 iron-bar buckles.
2,440 iron-roller buckles.
130 canteen corks.
567 canteen corks and chains.
1,562 canteen covers.
206 canteen strap snap hooks.
180 cincha or girth straps.
1,309 coat straps, saddle.
50 coat strap sliding loops.
58 cruppers.
731 curb straps.
24 dress-hat ornaments, cadet.
442 double-spring snap-hooks.
12,442 escutcheon pins.
1 guidon socket.
755 halter bolts.
64 halter chains.
694 halter squares.
121 lariat straps and snaps.
60 lariat snaps.
68 link snaps.
1,664 ovals.
1,842 brass rings, $1\frac{1}{4}$ inches.
168 iron D rings.
1,098 iron rings, $1\frac{7}{16}$ inches.
528 iron rings, $2\frac{1}{2}$ inches.

171	saber-belt snap-hooks.
60	saber-belt slides, brass.
915	saber straps.
230	saddlebag studs.
140	saddlebag stud rivets.
226	saddle nails, japanned.
180	side-line fasteners.
90	shields.
474	staples, foot, brass.
2,349	staples for rings, brass.
50	waist-belt sliding loops.

PARTS OF CLASS VIII.

Cartridge bags.

2,248	6-pounder gun.
4,955	12-pounder gun.
600	12-pounder howitzer.
500	32-pounder gun.
1,602	3-inch rifle.
602	3.2-inch rifle.
2	3.6-inch rifle.
8	3.6-inch mortar.
500	4.5-inch gun.
2	5-inch rifle.
2	7-inch rifle.
2	7-inch howitzer.
500	8-inch gun.
413	8-inch rifle.
1,8_0	10-inch gun.
4	10-inch rifle.
2	11-inch rifle.
6	12-inch rifle.
4	12-inch mortar.
362	15-inch gun.

PARTS OF CLASS IX.

3	lowering valves, hydraulic jack.
3	rain packings, hydraulic jack.

PART SECOND.

CLOTH, ROPE, THREAD, ETC.

17,419	yards cotton cloth.
5	yards cotton duck.
30	yards oiled duck.
483½	pounds cotton waste.
9	pounds Hambro line.
900	feet lashing line.
65½	pounds marline.
4,504½	pounds rope.
12	pieces sash cord.
160¾	pounds sash cord.

108 3/16 pounds patent thread.
492 1/2 pounds shoe thread.
89 1/2 pounds twine.
328 yards webbing.
55 pounds yarn.

IRONMONGERY.

2 faucets.
14 hasps.
14 hinges.
18,100 horseshoes.
1,630 pounds horseshoe nails.
1 inspirator, boiler.
1,120 pounds bar iron.
175 pounds iron nails.
242 padlocks.
3/16 pound brass rivets.
159 3/4 pounds brass rivets and burrs.
1,475 5/6 pounds copper rivets and burrs.
72 iron rivets.
56 5/6 pounds iron rivets and burrs.
19,706 brass screws.
2,076 iron screws.
576 screw eyes.
14 staples.
10 pounds bar steel.
440 pounds toe steel.
21,404 copper tacks.
89 1/8 pounds copper tacks.
1,981,900 iron tacks.
12 papers iron tacks.
42 1/2 pounds iron tacks.
31 pounds copper wire.
1,000 feet wire rope.

LEATHER, ETC.

2 sides alum-tanned leather.
1,129 sides bridle leather.
3 sides lace leather.
9,767 pounds harness leather.
117 1/2 quarts leather blacking.
262 3/4 pounds black wax.
14 1/4 ounces bristles.
98 boxes ingredients for leather blacking.

LUMBER.

1,932 feet boards.
256 feet plank.
160 feet scantling.
292 feet timber.

CLEANING, HEATING, AND LIGHTING.

43 bath bricks.
239 corn brooms.

28	bath brushes.
189	button brushes.
18	dusting brushes.
28	wire scratch brushes.
166	button sticks.
145	pounds candles.
259	chamois skins.
16	boxes cleaning material.
23	cleaning plates.
19,700	pounds coal.
59½	quires crocus cloth.
1,057¼	quires emery cloth.
51½	quires emery paper.
5	lanterns.
19	lantern globes.
544	pounds leather polish.
39	pounds Putz pomade.
358½	pounds rotten stone.
98	quires sand-paper.
1,076	ounces scouring material.
2,211½	pounds castile soap.
55	pounds common soap.
59½	pounds harness soap.
208	pounds sponge.
974	papers tripoli.
1,282	ounces whiting.

PARTS ARMY COAL HEATERS.

50	pairs doors and hinges.
100	door pins.
25	feed doors.
50	lids.
100	sections.
25	taps.
30	tap plates.

OFFICE MATERIAL.

1	set colored ink.
22	bottles India ink.
71	instruction books.
20	yards blue process paper.
59	yards cross-section paper.
20	yards brown drawing paper.
37	yards white drawing paper.
130	pounds petroleum paper.
56	lead pencils.
3	rubbers, elliptical.
4	seal stamps.
10	pounds sealing wax.
158	thumb-tacks.
60	yards tracing cloth.

LABORATORY MATERIAL.

5	gallons carbolic acid.
5	pounds muriatic acid.

86 gallons alcohol.
86⅝ pounds beeswax.
31 pounds white chalk.
20 pounds ammoniated sulphate of copper.
300 pounds sulphate of copper.
1 barrel rye flour.
8 pounds extract logwood.
500 pounds laboratory paper.
75 pounds chlorate of potash.
50 pounds nitrate of strontia.
40 pounds beef tallow.
1,534 pounds Japan wax.
10 gallons whisky.

OIL PAINT, ETC.

59¼ gallons Japan drier.
4 pounds oak graining.
10 pounds walnut graining.
28¼ gallons lacker.
26 pounds lampblack.
480 pounds white lead.
10 pounds French ocher.
33 quarts anticorrosive oil.
10 pounds cosmic oil.
85¾ gallons cosmoline oil.
10 gallons cylinder oil.
4,044 pounds harness oil.
186¼ gallons kerosene oil.
10 gallons lard oil.
391 gallons boiled linseed oil.
158 7/16 gallons raw linseed oil.
92½ gallons neats-foot oil.
833½ gallons neutral oil.
1 quart porpoise oil.
815⅜ gallons sperm oil.
603 pounds Bessemer paint for carriage.
928 pounds black paint.
3,538 pounds brown metallic paint.
20 pounds chrome-green paint.
200 pounds lead-color paint.
1,799 pounds olive paint.
10 pounds red paint.
35 pounds 3.2-inch gun paint.
725 pounds 3.2-inch gun-carriage paint.
21 pounds vermillion paint.
13 pounds white paint.
35 pounds putty.
25 pounds sienna.
324 gallons coal tar.
499½ gallons turpentine.
15 pounds umber.
18 gallons asphalt varnish.
1 gallon flint varnish.
10 gallons shellac varnish.
10 pounds vermilion.

MISCELLANEOUS.

4	anchors.
361	arm chests.
3	powder barrels.
4	cleaning-material boxes.
2	powder canisters.
3	cartridge holders, wood,
4	powder cases, zinc.
3	field cases, shot-gun supplies.
4	chamois-skin saber cases.
301	metallic powder kegs.
500	brass plates for trophy guns.
100	shelter tents, Bell.
1	steel stamp, ordnance escutcheon.
693½	pounds wheel grease.

INSPECTING INSTRUMENTS.

2	apparatus for suspending caliper.
1	caliper arm, steel.
2	caliper arms, wood, sets.
1	caliper arms-supporting saddle, steel.
1	caliper vernier.
2	sets measuring and fixed points, exterior diameter.
2	sets measuring and fixed points, interior diameter.
1	micrometer for surface lengths.
2	micrometer point cases.
4	pairs plates for 12-inch bore.
5	pressure gauges.
300	pressure-gauge cylinders.
5	exterior star gauge rests.
5	interior star-gauge rests.
1	step gauge.
5	transoms with rollers.

TOOLS.

2	adzes.
6	anvils.
120	aprons.
3	axes.
26	axe handles.
2	awls, peg, handled.
4	awls, seat.
435	awls, stitching.
2	awls, stub.
11	awl handles, patent.
109	awl handles, plain.
7	bits, assorted.
8	bits, auger.
7	bits for brace.
4	braces.
2	brushes, fitch.
241	brushes, paint.
78	brushes, sash.
8	brushes, stencil.

1 brush, varnish.
2 brushes, wall.
8 brushes, whitewash.
6 buckets, iron.
1 buttress.
9 calipers.
20 chalk lines.
8 chisels, assorted.
20 chisels, cold.
5 chisels, cold iron.
6 chisels, hot iron.
1 chisel, framing.
12 clamps, stitching.
19 claw tools.
17 clinching-irons.
41 compasses.
17 creasers, iron.
5 creasers, wood.
1 die-stock.
4 die-stocks and dies.
2 dies and taps.
6 drifts.
6 dustpans.
33 edge tools.
280 files.
20 file handles.
2 flatters.
5 fullers.
6 funnels.
21 gauges, draw.
2 grindstones, with arbor and crank.
41 hammers, assorted.
6 hammers, claw.
24 hammers, hand.
25 hammers, riveting.
19 hammers, saddler's.
2 hammers, set.
42 hammers, shoeing.
8 hammers, sledge.
65 hammer handles.
12 hardies.
6 hatchets.
13 horses, stitching.
1 jackscrew.
63 knives, assorted.
1 knife, drawing.
14 knives, half round.
15 knives, head.
2 knives, putty.
6 knives, shoe.
77 knives, shoeing.
21 knives, splitting.
18 knives, toe.
6 machine-shop tools, sets.
12 magazine slippers, pairs.
21 mallets.

6 marline spikes.
10 mauls.
4 measures, tin.
4 needles, collar.
525 needles, glovers'.
4,319 needles, harness.
53 nippers.
12 oilers, brass.
19 oil cans.
19 oil stones.
1 palm, sewing.
2 planes, assorted.
14 pickax handles.
4 pincers, paring.
60 pincers, shoeing.
6 pliers.
3 pokers.
23 pricking carriages, with wheels.
4 pricking wheels.
12 pritchels.
41 punches, assorted.
2 punches, center.
9 punches, hand, No. 4.
38 punches, nail, hand.
11 punches, nail and clinch knife.
2 punches, revolving.
16 punches, round.
10 punches, saddle.
49 punches, spring.
7 punches, square.
4 punching blocks, lead.
1 rake.
891 rasps, shoeing.
5 rasps, wood.
3 riveting irons.
16 rivet sets.
34 rules, 2 feet.
32 sandstones.
2 saws, crosscut.
1 saw, hand.
1 saw, rip.
3 saw sets.
2 scales and weights.
4 scissors.
38 screw-drivers, assorted.
23 screw-drivers, crosshead.
4 screw taps.
6 scythes.
3 scythe snaths.
2 scythe stones.
24 shears.
5 shoeing boxes.
4 shovels.
7 slickers.
8 squares.
1 set stencil cutter, figures.

1 set stencil cutter, letters.
1 set stencils, figures.
1 tape line, linen, 100 feet long.
3 tapes, steel, 100 feet long.
6 tap screws.
16 thimbles.
15 ticklers.
44 tongs.
2 tool bags.
1 vise, assorted.
8 vises, bench.
1 vise, forge.
1 vise, hand.
4 wheelbarrows.
73 wrenches, double, barbette carriage.
2 wrenches, nut.
30 wrenches, screw.
15 wrenches, single, barbette carriage.
3 wrenches, tap.
1 wrench and tap for vent piece.

APPENDIX 4.

Statement of ordnance, ordnance stores, etc., distributed to the militia from July 1, 1892, to June 30, 1893, under sections 1661 and 1667, Revised Statutes United States.

CLASS I.

2 3 inch wrought-iron rifled guns.
8 3.2-inch breech-loading steel rifles.

CLASS II.

8 3.2-inch gun carriages, metallic.
8 3.2-inch limbers, complete.
6 3.2-inch caissons and limbers, complete.

CLASS III.

10 artillery collars.
26 sets artillery harness, 2 wheel horses.
24 sets artillery harness, 2 lead horses.
6 breech covers.
6 breech-sight covers.
6 combination screw-drivers, 3.2-inch rifle.
4 fuse blocks.
8 fuse cutters.
2 fuse gouges.
8 fuse wrenches.
6 fuse plug wrenches.
14 gunners' haversacks.
18 gunners' gimlets.
12 gunners' reamers.
6 handspikes, maneuvering.
2 handspikes, trail.
6 front-sight covers, 3.2-inch rifle.
2 lanyards.
14 lanyards, new pattern.
14 neck yokes, 3.2-inch carriage and limber.
6 pendulum hausses.
6 pendulum hausse seats.
4 pendulum hausse pouches.
6 prolonges.
22 priming wires.
12 primer pouches.

4 paulins, 12 by 12 feet.
5 paulins, 12 by 15 feet.
2 sponge buckets.
6 sponges and rammers, 3.2-inch gun, bore.
12 sponges and rammers, 3.2-inch gun, chamber.
6 sponge covers, 3.2-inch gun, bore.
12 sponge covers, 3.2-inch gun, chamber.
12 sponges and rammers, 3-inch gun.
2 sponge covers, 3-inch gun.
124 sponges, woolen, 3-inch gun.
2 sets implements for 3.2-inch gun.
2 tow hooks.
8 tompions.
2 tube pouches.
8 thumbstalls.
2 vent covers.
14 vent punches.
14 poles, 3.2-inch carriage, complete.
1 pole, 6-pounder limber.
6 spare poles.
12 pole props.
6 spare wheels.
20 linchpins, No. 1.
20 linch washers, No. 1.

Classes IV and V.

44 8-inch shot.
6 8-inch shell.
100 3-inch shell.
300 3-inch canister.
100 3-inch Hotchkiss case shot.
300 3-inch shell, time fuse.
100 3-inch Hotchkiss shell, percussion fuze.
75 3-inch shell, time fuse, fully prepared.
60 3.2-inch shell, fully prepared.

Class VI.

3,895 Springfield rifles, model 1884.
20 Springfield cadet rifles, model 1884.
20 Springfield rifles, 6-groove, long range.
2 Springfield rifles, officer's model.
226 Springfield carbines, model 1884.
1 Springfield shotgun and appendages.
273 Colt's revolvers, caliber .45.
1 Schofield-Smith and Wesson revolver, caliber .45.
2 swords and cases, brigadier-generals'.
41 sabers, cavalry officers', and cases.
84 officers' swords and cases.
570 sabers, light artillery
573 sabers, light cavalry.
36 swords, noncommissioned officers'.
1 sword, musician's.
146 hospital corps knives and scabbards.

CLASS VII.

APPENDAGES.

2 combination screw-drivers.
2,416 headless shell extractors.
130 jointed ramrods.
2,696 screw-drivers, model 1879.
2,666 wooden wiping rods, rifle.
50 wooden wiping rods, carbine.

HORSE EQUIPMENTS.

820 bridles, curb, cavalry.
200 bridles, watering.
51 curb bits.
10 curb straps.
30 cruppers.
60 carbine boots and straps.
60 coat straps, cavalry saddle.
10 housings for brigadier-general's saddle.
251 halters, complete.
6 halter straps.
31 hair girths.
350 horse covers with surcingle.
430 nose bags.
82 picket pins.
82 lariats.
82 links with snap.
955 saddles, leather covered, cavalry.
50 saddle blankets, artillery.
906 saddle blankets, cavalry.
10 saddle cloths, hair.
50 saddle cloths, general officers'.
22 saddle cloths, staff officers'.
33 saddle cloths, officers of artillery.
9 saddle cloths, officers of cavalry.
67 saddle cloths, officers of infantry.
260 pairs saddle bags, black leather.
230 pairs spurs and straps.
21 pairs spurs and straps, officers.
25 pairs stirrups and straps.
7 stirrups with hoods.
6 stirrups with hood and socket.
25 sweat leathers.
4 surcingles.
10 side lines.
20 bridle reins.
20 throat latches.
2 double spring snaps for lariats.
6 snap hooks for lariats.
6 snap hooks for links.
6 brass staples.
10 brow bands.
6 brow band ornaments.
36 buckles for bridles.

6 buckles for links.
6 buckles for surcingles.
6 buckles for saddlebags.
6 cheek pieces.
6 cantle rings.
6 rings for lariats.
2 O-rings, brass.
3 saddlebag studs.

INFANTRY EQUIPMENTS.

5,836 bayonet scabbards.
3,753 blanket bags.
3,803 pairs blanket-bag shoulder straps.
4,053 pairs blanket-bag coat straps.
7,984 canteens and straps.
200 canteens.
2,469 cartridge boxes.
5,508 cartridge belts and plates.
40 cartridge belts with buckle.
80 canteen straps with snap.
80 haversack straps for cavalry.
5,319 haversacks and straps.
8,811 gun slings.
200 hook attachments for bayonet scabbards.
90 belt buckles for officers' belts.
37 officers' sword belts, complete.
2,846 waist belts and plates.
50 waist-belt plates.
15 waist belts and plates, noncommissioned officers'.
19 frogs, sliding, noncommissioned officers'.
76 waist belts and plates, hospital corps knives.
15,198 meat cans.
14,300 tin cups.
14,973 knives.
14,973 forks.
14,408 spoons.

ARTILLERY ACCOUTERMENTS.

484 artillery saber belts.
481 light-artillery knapsacks.

CAVALRY EQUIPMENTS.

411 carbine slings and swivels.
271 pistol holsters.
32 pistol cap pouches.
893 saber belts, complete.
140 saber knots.

CLASS VIII.

150 blank cartridges, 12-pounder gun.
500 blank cartridges, 6-pounder gun.

2,850	blank cartridges, 3-inch rifle.
50	blank cartridges, 3.2-inch rifle.
1,905,000	rifle ball cartridges, caliber .45.
167,000	carbine ball cartridges, caliber .45.
20,000	revolver ball cartridges, caliber .45.
417,000	rifle and carbine blank cartridges, caliber .45.
9,000	revolver blank cartridges, caliber .45.
600,000	rifle ball cartridges, caliber .50.
9,000	rifle blank cartridges, caliber .50.
4,000	carbine bullets, caliber .45.
371,000	rifle bullets, caliber .45.
340,000	round balls (140 grains).
5,000	primed cartridge shells (rifle), caliber .45.
100	pounds cannon powder.
1,000	pounds small-arms powder.
1,750	pounds sphero-hexagonal powder.
52	cartridge bags, 8-inch rifle.
300	cartridge bags, 3-inch rifle.
444,000	cartridge primers.
23,000	friction primers.
100	time fuses for 3-inch shell.

MISCELLANEOUS.

2	anchors.
173	arm chests.
59	boxes cleaning material.
4	bullet molds (casting 4 balls).
12	stop screws for bullet mold.
7	arm-racks for rifles.
450	marksmen's buttons.
7	distinguished marksmen's badges.
12	silver bars for sharpshooters' badges.
55	sharpshooters' badges.
32	chamois-skin sword cases.
32	sets hand reloading tools.
9	sets bench reloading tools.
1	floating target.
45	targets for gallery practice, 50 feet range.
10	targets for gallery practice, 75 feet range.
252	target frames.
10	signal flags.
1,063	cloth silhouettes.
1,915	paper silhouettes.
160	yards cotton cloth for targets.
1,253,000	pasters.
6,755	paper targets.
10	shot marks and staves, mid range.
257	pounds manila rope.
50	marking rods, disks, and brushes.

PARTS OF SPRINGFIELD RIFLES, CALIBER .45.

204	bridles.
421	bridle screws.

126 breechblocks.
36 breech screws.
60 breechblock caps.
170 breechblock cap screws.
36 butt-plate screws.
25 barrels.
200 bayonets.
110 bayonet clasps.
346 bayonet-clasp screws.
162 cam latches.
496 cam-latch springs.
722 extractors.
1,136 ejector springs.
950 ejector-spring spindles.
50 ejector studs.
3,168 firing pins.
896 firing-pin screws.
708 front sights.
408 front-sight pins.
195 front-sight covers.
10 front-sight cover screws.
25 guards, complete.
76 guard screws.
286 guard-bow swivels.
386 guard bow swivel screws.
98 hinge pins.
444 hammers.
18 locks, complete.
132 lower bands.
12 leaf slide binding screws.
100 mainsprings.
221 mainspring swivels.
175 mainspring-swivel rivets.
361 rear sights.
150 rear sight screws, front.
675 rear-sight screws, rear.
10 rear-sight leaf slides.
10 rear-sight fixed bases.
10 rear-sight movable bases.
18 ramrods.
36 ramrod stops.
1,074 sears.
272 sear springs.
1,122 sear screws.
112 sear spring screws.
186 side screws.
86 side-screw washers.
120 sight-protector bands.
154 spring rises.
120 stocks, complete.
179 stocks (wood part).
70 thumb pieces.
1,455 tumblers.
1,758 tumbler screws.
530 tumbler punches.

86 tang screws.
100 tip screws.
97 upper bands.
12 windage screws.
12 windage screw head pins.

PARTS OF SPRINGFIELD RIFLES, CALIBER .50.

400 firing pins.
100 ramrods.

APPENDIX 5.

Statement of ordnance, ordnance stores, etc., distributed to colleges from July 1, 1892, to June 30, 1893, under section 1225, Revised Statutes United States, as amended by act approved July 5, 1876.

CLASS I.

18 3-inch wrought-iron guns.

CLASS II.

18 3-inch gun carriages and limbers.

CLASS III.

18 gunners' haversacks.
18 handspikes, trail.
36 lanyards.
18 priming wires.
8 pendulum hausses.
8 pendulum-hausse seats.
8 pendulum-hausse pouches.
36 thumbstalls.
18 tube pouches.
18 tompions.
18 vent covers.
18 paulins, 12 by 15 feet.
36 sponges and rammers, 3-inch.
36 sponge covers, 3-inch.
1 worm and staff, 3-inch.

CLASS VI.

2,244 Springfield cadet rifles, model 1884.
70 sabers, cavalry.
2 swords, noncommissioned officers'.

CLASS VII.

2,244 headless-shell extractors.
2,244 screw-drivers, model 1879.
2,244 wooden wiping rods.
453 tumbler punches.
119 spring vises.
3,652 bayonet scabbards.

2,502 cartridge boxes, McKeever.
2,496 waist belts and plates.
441 gunslings.
70 saber belts and plates.
2 waist belts and plates, noncommissioned officers'.
2 frogs, sliding, noncommissioned officers'.

CLASS VIII.

200 blank cartridges, 12-pounder gun.
200 blank cartridges, 6-pounder gun.
3,390 blank cartridges, 3-inch gun.
100 blank cartridges, 3.2-inch gun.
7,000 rifle ball cartridges.
112,500 carbine ball cartridges.
81,000 carbine blank cartridges.
12,250 carbine bullets (405 grains).
29,000 round balls (140 grains).
47,000 cartridge primers.
11,000 friction primers.
475 pounds small-arms powder.

CLASS IX.

120 arm chests.
147,500 pasters.
1,500 paper targets.
300 centers for targets.
200 targets for gallery practice, 50-feet range.
8 sets hand-reloading tools.
7 bullet molds (casting 4 balls).
4 melting ladles, 7-inch.
4 pouring ladles, 2-inch.
10 pounds lubricant.

PARTS OF SPRINGFIELD CADET RIFLES, MODEL 1884.

19 bayonets.

APPENDIX 6.

Statement of ordnance stores issued to the Executive Departments during the year ended June 30, 1893, under the provisions of the act of March 3, 1879.

TO THE TREASURY DEPARTMENT.

20 Springfield carbines.
250 carbine ball cartridges.
1,500 rifle ball cartridges.
1,000 rifle and carbine blank cartridges.
500 revolver ball cartridges.

TO THE STATE DEPARTMENT.

12 Springfield rifles.
1,000 rifle-ball cartridges.

APPENDIX 7.

Report of action taken under the act of March 3, 1881, during the fiscal year ended June 30, 1893.

SOLD.

To Hartley & Graham.

1892.			
Sept. 6.	520,600	elongated ball cartridges, caliber .69, at $6 per M...	$3,123.60
	235,000	buck and ball cartridges, caliber .69, at $6 per M...	1,410.00
		Total proceeds	4,533.60

PURCHASED.

From Hotchkiss Ordnance Co.

1892.			
Nov. 25.	2	pounds smokeless powder, at $1.93 per pound.....	$3.86
		Total purchased	3.86

APPENDIX 8.

SHOWING THE STATIONS AND DUTIES OF THE OFFICERS OF THE ORDNANCE DEPARTMENT ON OCTOBER 1, 1893.

Rank and name.	Duty and station.	Address.
BRIGADIER-GENERAL.		
1. D. W. Flagler	Chief of Ordnance	Washington, D. C.
COLONELS.		
1. J. M. Whittemore	Commanding the United States Powder Depot.	Dover, N. J.
2. A. R. Buffington	Commanding the Rock Island Arsenal	Rock Island, Ill.
3. A. Mordecai	Commanding the Springfield Armory	Springfield, Mass.
LIEUTENANT-COLONELS.		
1. F. H. Parker	Commanding the Allegheny Arsenal	Pittsburgh, Pa.
2. J. P. Farley	Commanding the Frankford Arsenal	Philadelphia. Pa.
3. L. S. Babbitt	Commanding the Benicia Arsenal	Benicia, Cal.
4. W. A. Marye	Commanding the Fort Monroe Arsenal	Fort Monroe, Va.
MAJORS.		
1. I. Arnold, jr	Commanding the Watervliet Arsenal, and president of Board for Testing Rifled Cannon, etc.	West Troy, N. Y.
2. C. Comly	Commanding the New York Arsenal, president of the Ordnance Board, member of Board for Testing Rifled Cannon, etc., member of the Board of Ordnance and Fortification, and member of Board Government Exhibit at the World's Columbian Exposition, Chicago, Ill.	Governors Island, New York City. P. O. box 1449.
3. J. R. McGinness	Commanding the Kennebec Arsenal	Augusta, Me.
4. F. H. Phipps	Chief ordnance officer, Department of the Missouri.	Chicago, Ill.
5. J. W. Reilly	Commanding the Watertown Arsenal, and member of Board for Testing Rifled Cannon, etc.	Watertown, Mass.
6. J. A. Kress	Commanding St. Louis Powder Depot	Jefferson Barracks, Mo.
7. C. E. Dutton	Commanding the San Antonio Arsenal, and chief ordnance officer, Department of Texas.	San Antonio, Tex.
8. J. G. Butler	Commanding the Augusta Arsenal	Augusta, Ga.
9. C. Bryant	On duty at Watervliet Arsenal	West Troy, N. Y.
10. A. L. Varney	Commanding the Indianapolis Arsenal	Indianapolis, Ind.
CAPTAINS.		
1. J. E. Greer	Commanding the Columbia Arsenal	Columbia, Tenn.
2. J. Pitman	On duty at Frankford Arsenal	Philadelphia, Pa.
3. C. Shaler	Principal assistant in the Ordnance Bureau.	Washington, D. C.
4. H. Metcalfe	On sick leave	Cold Spring, N. Y.
5. C. S. Smith	On duty in the office of the Chief of Ordnance.	Washington, D. C.
6. S. E. Blunt	On duty at Springfield Armory	Springfield, Mass.
7. F. Heath	Commanding the Sandy Hook Proving Ground, member of Board for Testing Rifled Cannon, etc., and member of the Ordnance Board.	Governors Island, New York City. P. O. box 1449.
8. D. M. Taylor	On duty at Springfield Armory, and member of the Board for Testing Range and Position finders.	Springfield, Mass.
9. D. A. Lyle	On inspection duty at the Midvale Steel Works, Nicetown, Philadelphia, Pa., and member of Board on Life-Saving Apparatus, etc., under the Secretary of the Treasury.	P. O. box 1606, Philadelphia, Pa.

SHOWING THE STATIONS AND DUTIES OF THE OFFICERS OF THE ORDNANCE DEPARTMENT ON OCTOBER 1, 1893—Continued.

Rank and name.	Duty and station.	Address.
CAPTAINS—continued.		
10. J. Rockwell, jr	On duty at Watervliet Arsenal	West Troy, N. Y.
11. J. C. Ayres	Commanding the Omaha Ordnance Depot, and chief ordnance officer Department of the Platte.	Omaha, Nebr.
12. M. W. Lyon	On inspection duty at the Builders' Iron Foundry, Providence, R. I.	22 Codding street, Providence, R. I.
13. C. W. Whipple	On duty in the office of the Chief of Ordnance.	Washington, D. C.
14. A. H. Russell	In charge of ordnance exhibit World's Columbian Exposition.	Government building, Jackson Park, Chicago, Ill.
15. R. Birnie	On duty in the office of the Chief of Ordnance.	Washington, D. C.
16. I. MacNutt	On inspection duty at the Bethlehem Iron Works, South Bethlehem, Pa.	South Bethlehem, Pa.
17. C. C. Morrison	On duty at Sandy Hook Proving Ground, and recorder of Board of Ordnance and Fortification.	Governors Island, New York City. P. O. box 1449.
18. F. Baker	On duty at Watertown Arsenal	Watertown, Mass.
19. O. B. Mitcham	Watervliet Arsenal (on sick leave)	West Troy, N. Y.
20. H. D. Borup	On inspection duty at the works of Robert Poole & Son Co., Baltimore, Md.	Baltimore, Md.
21. L. L. Bruff	Instructor of ordnance and gunnery, U. S. Military Academy.	West Point, N. Y.
22. C. H. Clark	On duty at Frankford Arsenal	Philadelphia, Pa.
23. William Crozier	Member of the Ordnance Board	Governors Island, New York City. P. O. box 1449.
24. W. B. Gordon	On inspection duty at West Point Foundry, Cold Spring, N. Y., and inspector of pneumatic dynamite guns.	Cold Spring, N. Y.
25. F. E. Hobbs	On duty at Watervliet Arsenal	West Troy, N. Y.
FIRST LIEUTENANTS.		
1. S. E. Stuart	On inspection duty at the Bethlehem Iron Works, South Bethlehem, Pa.	South Bethlehem, Pa.
2. J. W. Benét	On duty at Frankford Arsenal	Philadelphia, Pa.
3. W. W. Gibson	On duty at Watertown Arsenal	Watertown, Mass.
4. E. B. Babbitt	Assistant instructor of ordnance and gunnery, U. S. Military Academy.	West Point, N. Y.
5. O. M. Lissak	On duty at Benicia Arsenal	Benicia, Cal.
6. B. W. Dunn	On duty at San Antonio Arsenal	San Antonio, Tex.
7. John T. Thompson	On duty at Rock Island Arsenal	Rock Island, Ill.
8. Charles B. Wheeler	On duty at Sandy Hook Proving Ground	Governors Island, New York City. P. O. box 1449.
9. F. P. Peck	On duty at Sandy Hook Proving Ground, and member of Board for Testing Rifled Cannon, etc.	Governors Island, New York City. P. O. box 1449.
10. W. S. Peirce	On duty at Watervliet Arsenal	West Troy, N. Y.
11. George W. Burr	On duty at Allegheny Arsenal	Pittsburg, Pa.
ORDNANCE STOREKEEPERS. CAPTAINS.		
1. A. S. M. Morgan	On duty at Allegheny Arsenal	Pittsburg, Pa.
2. W. H. Rexford	On duty at Springfield Armory, with rank of major.	Springfield, Mass.
3. M. J. Grealish	On duty at Rock Island Arsenal	Rock Island, Ill.
4. V. McNally	On duty in the office of the Chief of Ordnance.	Washington, D. C.

APPENDIX 9.

REPORT OF A BOARD OF OFFICERS CONVENED UNDER THE PROVISION IN THE ACT OF CONGRESS APPROVED FEBRUARY 27, 1893, TO TEST MAGAZINE RIFLES OF AMERICAN INVENTION.

(7 plates.)

BOARD OF ORDNANCE AND FORTIFICATION,
WAR DEPARTMENT,
Washington, D. C., May 26, 1893.

SIR: At the meeting of the Board of Ordnance and Fortification of the 25th instant the following action was taken on the report of the Board on Magazine Small Arms convened in obedience to the General Order No. 16, series of 1893, viz:

The act of Congress approved February 27, 1893, "making appropriations for the support of the Army for the fiscal year ending June 30, 1894, and for other purposes," provides "For manufacture of arms at the national armories, four hundred thousand dollars: *Provided*, That no part of this appropriation shall be expended for the manufacture of magazine rifles of foreign invention until such magazine rifles of American invention as may be presented for test to the War Department within the next thirty days shall have been tested by a board of officers to be selected by the Secretary of War, which board shall report to the Board of Ordnance and Fortification on or before July first, eighteen hundred and ninety-three. If the decision of said board of officers shall be in favor of any American invention and shall also receive the approval of the Board of Ordnance and Fortification and the Secretary of War, then this appropriation, or such part thereof as the Secretary may direct, shall be expended in the manufacture of such American arm: *Provided further*, That if no such American invention shall be recommended by said board or receive the approval of the Secretary of War this appropriation shall be applicable to the manufacture of the magazine arm recommended for trial by the board recently in session and approved by the Secretary of War."

The board considered the report of the above-mentioned board dated May 16, 1893, and finds that no American invention has been recommended by it, and therefore forwards the report to the honorable the Secretary of War without further action, in accordance with the terms of the act, which only call for a recommendation from the Board of Ordnance and Fortification in case "the decision of said board of officers shall be in favor of any American invention."

In accordance with the above action the report of the Board on Magazine Small Arms is respectfully forwarded herewith.

For the board.

Very respectfully,

J. M. SCHOFIELD,
Major-General, U. S. Army, President of the Board.

The honorable the SECRETARY OF WAR.

OFFICE OF THE BOARD ON MAGAZINE ARMS,
SPRINGFIELD ARMORY,
Springfield, Mass., May 16, 1893.

GENTLEMEN: I have the honor to submit herewith the report of the Board on Magazine Arms of American invention.

The journal of proceedings with drawings and descriptions of the guns submitted for examination and synopsis of their trials are forwarded in separate packages.

The guns tested have been given into the custody of the commanding officer, Springfield Armory.

Very respectfully, your obedient servant,

ELWELL S. OTIS,
Colonel, Twentieth Infantry, President of the Board.

BOARD OF ORDNANCE AND FORTIFICATION,
Washington, D. C.

OFFICE OF THE BOARD ON MAGAZINE ARMS,
SPRINGFIELD ARMORY,
Springfield, Mass., May 16, 1893.

SIR: The board was originally constituted by General Orders No. 16, Headquarters of the Army, Adjutant-General's Office, March 1, 1893, and directions were therein given for its procedure.

A change in its membership was announced in General Orders No. 33, Headquarters of the Army, Adjutant-General's Office, April 25, 1893, and made in its instructions by letters from the Secretary of War, directing the board to receive arms of other caliber than .30 (see record of proceedings for March 30, 1893) and extending till April 30, 1893, the time within which arms could be submitted (see record of proceedings for April 18, 1893).

Within the period prescribed in the original order thirteen guns were presented for test by eight persons.

Within the second period an arm which had been tested within the first period was resubmitted with a slight modification. The system was unchanged.

A list of all these guns, with the exhibitors' addresses, the dates when the arms were received by the board, their descriptions, and a synopsis of their tests is given elsewhere in this report.

The board is of opinion that a magazine arm of small caliber best adapted to the needs of the United States military service should conform to the following principal conditions:

First. It is essential that the arm be susceptible of use as a single loader with magazine held in reserve, and also well adapted for such use where the magazine is empty.

Second. The cut-off should be so prominent as to be readily observed by the squad leaders, but not so placed as to be liable to be inadvertently operated by the soldier, and must be capable of easy operation when so desired, whether the magazine be empty or full.

Third. It is desirable that the magazine may be charged whether the cut-off be arranged for single or magazine fire.

Fourth. It is essential that the magazine may be readily loaded or replenished with single cartridges.

Fifth. It is desirable that the magazine be susceptible of easy loading from auxiliary chargers or packets, and essential that these chargers or packets form no part of the magazine mechanism.

Sixth. It is essential that the floor of the receiver be of such form that cartridges can be laid upon it and, without assistance of the hand, pushed by the bolt into the chamber, and this whether the magazine be empty, or charged and held in reserve.

Seventh. It is desirable that the bolt be in one piece, a separate bolt-head being considered objectionable.

Eighth. It is essential that the bolt be sustained under the force of discharge by a lug, or lugs, at its forward end, and it is desirable that an auxiliary support be provided further to the rear either by a rib on the bolt, or by the base of the handle, or by both these means.

Ninth. It is essential, for ease of manipulation, that the initial movement in unlocking the bolt and starting the empty shell be given by a motion of rotation, bringing into play the assistance offered by cams on the bolt, breech casing, or receiver, and that the final seating of the cartridge and locking of the bolt be accomplished in a similar manner.

Tenth. It is desirable that the greater amount of compression of the mainspring be accomplished by these two movements.

Eleventh. It is essential that the bolt should be locked before the firing pin can reach the primer.

Twelfth. It is desirable in case of misfire that the piece may be recocked without moving the bolt.

Thirteenth. It is desirable that the extractor be strong and not partake of the bolt's rotation.

Fourteenth. It is desirable that the ejector throw the empty shell clear of the gun and soldier, but without excess of force.

Fifteenth. It is essential that the mechanism be strong and simple, composed of as few parts as possible, readily dismounted without the use of special tools, and assembled with a minimum number of screws or pins.

Sixteenth. It is essential that the easy and smooth working of the mechanism, whether the gun be clean or foul, be not sacrificed for extreme rapidity of action.

Bearing in mind these requisites, and also the manner in which the guns tested performed under trial, the board reports as follows of the different systems:

No. 1, Spencer-Lee.—Breechblock insufficiently supported for modern cartridges; method of operation awkward and difficult. System unsuited to the military service.

No. 2, Lee, Model 1893.—The direct motion of the bolt a serious defect. Method of locking defective and insecure. Method of compressing mainspring and force required to accomplish it, and to close and lock bolt, undesirable and excessive. The cut-off not sufficiently prominent. There being no floor to receiver it is necessary when using the gun as a single-loader, with magazine empty, to insert the cartridges with the fingers well into the chamber; a serious defect. The mechanism is complicated, difficult to dismount and assemble, some of its parts are of insufficient strength, and the system is unsuited to the military service.

No. 3, Savage.—Excessive force required to operate the mechanism, which fails to fulfill most of the previously enumerated requisites. The bolt is moved by a long lever lying below the stock and behind the receiver; a serious defect. The system is unsuited to the military service.

Nos. 4, 5, 6, and 7.—All upon the Durst system and having no material points of difference. While conforming to some of the standard conditions the following defects of the system are noted:

The locking of the bolt at the rear of the receiver, instead of just back of the chamber.

The great force required to operate mechanism when gun is foul.

The difficulty in moving cut-off after magazine is fully charged or when gun is foul, and yet the possibility, when the gun is clean, of the soldier in rapid firing unintentionally moving the cut-off.

The excessive weakening of the chamber by the three cuts for cartridge stop and extractors.

The compression of the mainspring principally by direct action.

The use of a double extractor and the method by which the hold of one upon the cartridge is released.

The long separate bolthead.

The long wound magazine spring, which would require in service frequent adjustment of its tension, an operation demanding considerable time and attended with difficulty.

The length of time required to charge the magazine with single cartridges.

The difficulty attending the stripping of cartridges from loading clips and especially the force required to push the last one or two into the magazine.

The guns on this system submitted to the board were arranged for cartridges without flanged heads, which are stripped from clips to the magazine. This method is impracticable for cartridges like the new small-caliber service cartridge of the U. S. Army, the heads of which are flanged.

The system is not suited to the military service.

No. 8, Blake.—The system violates a number of the standard conditions. Great force is required to operate the mechanism; the cut-off can be moved and the magazine loaded only when the bolt is in a particular position.

The cartridge packet, besides being an essential portion of the magazine, in itself a serious defect, is bulky and awkward to carry and not easy of insertion in the magazine box.

The system is not suited to the military service.

Nos. 9, 10, and 11.—All with magazine upon the Russell-Livermore pattern, but with the receiver and entire bolt mechanism the same as on the Lee-Speed, Mark I, of England.

The magazines are of the same general design, differing somewhat in the details of construction. All are awkward to load and operate.

They are not suited to the military service.

No. 12, White.—When subjected to the test of rapid or prolonged firing shown to be of defective construction.

The principal defects of the system are:

The direct motion of the bolt, the method of starting the empty shell, and the method of locking the mechanism.

After the handle has been retracted a short distance, a sudden and increased application of force is necessary. This often failed to withdraw the cartridge, when it became necessary to return the handle and repeat the effort.

In closing the bolt a similar difficulty was frequently observed, the same measures to overcome it being required.

The method of locking by a block moving transversely across the bolt.

The cartridge packet forms an essential portion of the magazine and without it magazine fire is impossible.

The cut-off is so situated that it is liable to be moved unintentionally by the soldier.

The magazine springs are uncertain in action.

The bolt is of insufficient strength and not easy to dismount and assemble.

The system is not suited to the military service.

No. 13, Hampden.—The magazine system as developed in this arm (working upon gravity alone) is in the principle employed and the detailed manner in which it is applied considered a failure. From its position the magazine limits the field of vision of the soldier and is particularly liable to injury. It is not suited to the military service.

No. 14, Blake No. 2.—This was the only arm submitted after the first period assigned in the original order, and before May 1, 1893. The system being identical with the Blake No. 1, it is, for the reasons previously stated, considered unsuited to the military service.

ELWELL S. OTIS,
Colonel, Twentieth Infantry.
J. C. BATES,
Colonel, Second Infantry.
ROBT. H. HALL,
Lieutenant-Colonel, Sixth Infantry.
H. B. FREEMAN,
Major, Sixteenth Infantry.
FRANCIS MOORE,
Major, Fifth Cavalry.
STANHOPE E. BLUNT,
Captain, Ordnance Department.

The PRESIDENT OF THE BOARD OF
ORDNANCE AND FORTIFICATION,
Washington. D. C.

PART I.—*Proceedings of the Board on Magazine Arms of American Invention.*

Proceedings of a board of officers convened by virtue of the following order:

GENERAL ORDERS, }
No. 16. }

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, March 1, 1893.

By direction of the Secretary of War, a board of officers will assemble at the Springfield Armory, Springfield, Mass., at 10 o'clock a. m., on Saturday, March 11, 1893, or as soon thereafter as practicable, for the purpose of testing and reporting upon such magazine rifles of American invention as may be presented for test to the War Department, in accordance with the provisions of the act of Congress making appropriations for the support of the Army for the fiscal year ending June 30, 1894, and for other purposes, approved February 27, 1893.

Detail for the board.

Col. Elwell S. Otis, Twentieth Infantry.
Lieut. Col. Robert H. Hall, Sixth Infantry.
Lieut. Col. Joseph P. Farley, Ordnance Department.
Maj. Henry B. Freeman, Sixteenth Infantry.
Capt. Stanhope E. Blunt, Ordnance Department.
Capt. George S. Anderson, Sixth Cavalry.
Capt. Blunt will act as recorder of the board.

The arms submitted must be of caliber .30 and must use the Frankford Arsenal experimental cartridge.

The Chief of Ordnance will supply such information and offer such facilities to the board in the trials and experiments undertaken as may be necessary to the performance of the duty assigned it.

The arms to be tested must be presented to the board at the Springfield Armory before March 31, 1893, and the board must complete its labors and make its report to the Board of Ordnance and Fortification on or before July 1, 1893.

The board is authorized to adjourn from time to time as may be found necessary, and upon final adjournment the members will return to their proper stations. The travel enjoined is necessary for the public service.

By command of Maj. Gen. Schofield.

R. WILLIAMS,
Adjutant-General.

Official:
WILLIAM J. VOLKMAR,
Assistant Adjutant-General.

SPRINGFIELD ARMORY,
Springfield, Mass., March 11, 1893.

The board met pursuant to the above order.

Present, all the members.

The order convening it having been read, the recorder then laid before the board the correspondence received by him since the issue of that order.

This included a letter (L. R. 1) from the Chief of Ordnance with reference to cartridges, requested by the recorder in anticipation of the meeting of the board, and also the following letter (L. R. 2) from the same officer:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, March 9, 1893.

SIR: I am instructed by the Chief of Ordnance to transmit herewith a supply of newspaper advertising slips, showing the time of the assembling of the Board for

Testing Magazine Rifles of American Invention at the Springfield Armory and the latest date upon which American inventions of magazine arms can be laid before the board, with request that you send one copy to all known American inventors of magazine rifles.

This office has distributed these advertisements to all American inventors shown on page 76 of the report of the Board on Magazine Small Arms.

Respectfully,

R. BIRNIE,
Captain, Ordnance Department, U. S. Army.

Capt. S. E. BLUNT,
Ordnance Department, U. S. Army,
Recorder of the Board for Testing Magazine Rifles of American Invention,
Springfield Armory, Springfield, Mass.

The replies and other communications of the recorder (Letter Book, pp. 1 to 3, inclusive) were also presented. After examination this correspondence was approved by the board.

The following letter (L. R. 3) was received from the Chief of Ordnance:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, March 8, 1893.

SIR: It is expected that applications will be addressed to the Board, as well as to this office, for parts of arms or ammunition, by inventors wishing to submit arms for trial by the board.

In view of this, and in order to offer such facilities to the board in the trials and experiments undertaken as may be necessary, and also to afford every possible assistance to inventors within the limited time allowed for the presentation of arms for trial, I have the honor to inform you that I have given instructions to the commanding officers of the Springfield Armory and Frankford Arsenal to sell to inventors, at cost price, any finished or partially completed parts of any arm or ammunition made by the Government that may be recommended for such disposition by the Board.

These officers will comply with requests that may be made by the board for information regarding the time in which orders can be filled, and will expedite their completion in every way practicable.

I request, therefore, that the board will act accordingly upon applications of this nature received by it, and when sales are to be made will communicate directly to that effect with the commanding officers named above.

Respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The PRESIDENT OF THE BOARD ON MAGAZINE ARMS,
Springfield Armory, Springfield, Mass.

The subject of the rules and tests that should govern in the examination and trials of guns that might be submitted was discussed at length, and the following finally adopted.

Generally these rules will govern in testing all guns submitted to the board, though it may occur that certain of these tests will be modified or others substituted for them.

The piece to be first fired ten rounds by the exhibitor as a test of safety, the same firing to be also a test of rapidity by one familiar with the arm, the time to be noted in the record.

The firing to be then continued, according to the rules annexed, by an employé or person designated by the board.

The Frankford Arsenal experimental cartridge to be used in all cases.

No persons will be admitted to the firing ground but the agents or exhibitors of the gun immediately under trial, and such other persons as may be specially invited by the board.

The handling of guns by their representatives at any time after the preliminary test for safety is forbidden.

Any arm which has been submitted to the board and entered upon the record shall remain in the hands of the board for such time as may be necessary to make drawings explanatory of its mechanism.

If the magazine system of any gun becomes disabled, or unserviceable, all further tests will be discontinued and the proprietor informed of the fact. If the gun be altered and resubmitted to the board it will be treated as a new gun.

SAFETY TEST:

To be fired ten rounds by the exhibitor, or with a lanyard.

REGULAR TESTS.

I.—Rapidity with Accuracy.

Piece to be fired from the shoulder at target 6 feet by 2 feet, range 100 feet, under following circumstances, cartridges disposed at will or in packets upon a table:

(*a*) Time of firing and number of hits for 20 shots; magazine to be loaded before beginning test and then held in reserve until remainder of cartridges have been fired, using gun as single loader; then firing those in magazine.

(*b*) Number of shots and hits firing for two minutes, using gun as single loader; test begun with chamber empty.

(*c*) Number of shots and hits firing for two minutes, using gun as magazine arm only; test begun with magazine empty.

Any cartridge missing fire in this or other tests to be tried with a prick punch, or opened, to ascertain cause of failure.

II.—Rapidity at Will.

Same as Test I, except that piece will be fired from the hip, without aim, at stop butt at short range; hits not considered, and time of firing for parts *b* and *c* reduced to one minute.

III.—Endurance.

(*a*) Each gun to be fired 500 continuous rounds without cleaning, using the magazine. The state of the breech mechanism to be examined at the end of every 50 rounds.

(*b*) With magazine loaded but held in reserve, each gun to be fired as a single loader 100 continuous rounds without cleaning; condition of breech mechanism and of the cartridges in magazine to be examined at conclusion of firing.

IV.—Dust.

With the mechanism closed, the piece to be exposed in the box prepared for that purpose to a blast of fine sand dust for two minutes, removed, surplus sand removed by blowing thereon and wiping with the bare hand, and then fired 20 rounds under the following conditions:

(*a*) Magazine empty when exposed. Before firing load magazine, fire balance of cartridges as a single loader, then those in magazine.

(*b*) Magazine loaded when exposed. Remove and wipe cartridges, reload and fire as above.

V.—Defective Cartridges.

Each gun to be fired once with each of the following defective cartridges: 1. Cross filed on head to nearly the thickness of the metal. 2. Cut at intervals around the rim. 3. With a longitudinal cut the

whole length of the cartridge, from the rim up. A fresh piece of white paper, marked with the number of the gun, being laid over the breech to observe the escape of gas, if any occur.

VI.—Excessive Charges.

The piece to be fired five times as a single loader with cartridges in which the charge of powder is so increased as to produce a pressure in the chamber about one-third greater than that caused by the Frankford Arsenal experimental cartridge.

VII.—Ease of Manipulation.

Facility of manipulation by members of the board.

Any gun whose breech action or magazine system fails in any of the foregoing tests will not be submitted to further tests.

SUPPLEMENTARY TESTS.*

I.—Defective Cartridges and Dust.

(*a*) As a single loader: To be fired with two defective cartridges, Nos. 1 and 2, and then to be dusted five minutes, the mechanism being in the mouth of the blow-pipe, and closed, but at full-cock; then to be fired 5 shots, the last two defective Nos. 1 and 2; then without cleaning to be dusted with the breech open and fired 5 shots. The piece to be freed from dust only by pounding or wiping with the bare hand.

(*b*) As a magazine arm: Same as *a*, except that the cartridges for the subsequent firing will be placed in the magazine before dusting, and fired therefrom afterwards.

II.—Rust.

The breech mechanism, receiver, and magazine to be cleansed of grease, and the chamber of the barrel greased and plugged, and breech action closed; the butt of the gun to be then inserted to the height of the chamber in a solution of salammoniac for 10 minutes, exposed for two days to the open air standing in a rack, and then fired 20 rounds, loading magazine and holding it in reserve until remainder of cartridges have been fired, using gun as single loader, then firing those in magazine.

III.—Explosions in Magazine.

The liability to accidental explosion of cartridges in tubular magazines will be tested by charging the magazine and then giving the gun a vertical jolting motion for 2 minutes, repeating with the magazine but half loaded.

IV.—Dismounting and Assembling.

The comparative ease and relative time required in dismounting and assembling the breech and magazine systems of the different guns will be determined.

To further determine the comparative rapidity of fire and facility of manipulation of various arms, each gun will be fired 20 shots by three men to be selected by the board, loading from the cartridge box

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*To be applied only to such arms as have passed through the regular tests in a manner satisfactory to the board.

and firing from the shoulder, with aim at an "A" target 100 yards distant. The average of the three trials to be the recorded time of firing 20 rounds. The magazine to be loaded from the cartridge box before the start, the remainder of the cartridges to be fired away first, using the gun as a single loader, and the magazine to be emptied last.

Such additional tests or repetition of previous ones as may seem advisable will be made by the Board in its discretion.

Mr. Herbert S. Dyer, of Portland, Me., then appeared before the Board, requested certain information, and exhibited a model of a sporting arm of his invention. He advised the board of his intention to present a military weapon at a later date.

Letters (Letter Book, pp. 4 and 5) were sent to the Adjutant-General of the Army with reference to the adjournment of the board, and to the Chief of Ordnance requesting authority to employ a clerk, draftsman, and mechanic.

The board directed that in intervals of any length which might occur between its sessions the recorder conduct such of its correspondence as might require prompt attention and where the concerted action of the board was not necessary.

No arms having been submitted for trial, nor any communications received from inventors, there was consequently no prospect that tests could be inaugurated for some days, and as there was no other business before it the board then adjourned to meet at the Springfield Armory on March 30, 1893.

SPRINGFIELD ARMORY,
Springfield, Mass., March 30, 1893.

The board met pursuant to adjournment. Present, all the members.

The recorder laid before the board the communications received by him since the last adjournment. These included letters requesting caliber 0.″30 dummy cartridges and information on various points, or making various suggestions from Webner E. Loomis, Springfield, Ill. (L. R. 6); Browning Bros., Ogden, Utah (L. R. 8); George S. Bartlett, Anaconda, Mont. (L. R. 28); A. D. Andrews, New York, N. Y. (L. R. 31); Lieut. Geo. H. Morgan, U. S. Army (L. R. 43); James C. Hall, New York, N. Y. (L. R. 45 and 50) and John Stevenson, Constantinople, Turkey (L. R. 48).

With reference to drawings or models they desired to submit, from A. J. Pocock, Dayton, Ohio (L. R. 23); Francis Bannerman, New York, N. Y. (L. R. 24 and 32); and George Fogerty, Cambridgeport, Mass. (L. R. 29).

Requesting caliber 0.″30 barrels or ammunition, from Lieut. Cassius E. Gillette, U. S. Army (L. R. 11); M. Sporer, Hartford, Conn. (L. R. 13); Maj. W. R. Livermore, U. S. Army (L. R. 19 and 27); Brooks Arms and Tool Company, Portland, Me. (L. R. 21); and John H. Blake, New York, N. Y. (L. R. 25, 33, and 35).

Reporting their guns would not be completed in time for submission at the date fixed in the order convening the Board, from James L. Smith, Hampton, Va. (L. R. 5); Browning Bros., Ogden, Utah (L. R. 20); and Webner E. Loomis, Springfield, Ill. (L. R. 41).

With reference to the guns they proposed to submit, from J. P. Lee, Hartford, Conn. (L. R. 7, 26, and 46); J. H. Acton, Aurora, Ill. (L. R. 10); Lieut. F. P. Fremont, U. S. Army and M. A. Durst, Hartford, Conn. (L. R. 9, 14, 17, 30, 38, and 44); Arthur Savage, Hartford, Conn.

(L. R. 15 and 18); Lieut. Cassius E. Gillette, U. S. Army (L. R. 47 and 52); John H. Blake, New York, N. Y. (L. R. 49); and A. D. Andrews, counsel for the White Magazine Rifle Company (L. R. 51).

From the Lee Arms Company, South Windham, Conn. (L. R. 37), desiring to submit the Lee Speed, Mark II of England.

From the commanding officer, Springfield Armory (L. R., 22, 34, 36, 40, and 42), with reference to barrels sent inventors, and (L, R., 53) with reference to draftsman for the board.

From the Chief of Ordnance, U. S. Army, authorizing the employment of clerk, draftsman, and mechanic for the board (L. R., 12), and also the following letter (L. R., 16):

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, March 16, 1893.

SIR: I am instructed by the Chief of Ordnance to transmit herewith a supply of printed slips showing time of assembling the Board for Testing Magazine Rifles of American invention at the Springfield Armory, and to invite your attention to the amendment therein under which the board in its discretion may allow arms of other caliber to be presented and tested, etc.

This office has distributed these advertisements to all American inventors shown on page 76 of the report of the Board on Magazine Small Arms.

Respectfully,

R. BIRNIE,
Captain, Ordnance Department, U. S. Army.

Capt. S. E. BLUNT,
Ordnance Department, U. S. Army,
Recorder of the Board for Testing Magazine Rifles of American Invention,
Springfield Armory, Springfield, Mass.

The replies of the recorder to these communications and his letters transmitting the slips above mentioned were also submitted (Letter Book, pp. 6 to 87 inclusive). The slips referred to were as follows:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, March 7, 1893.

A board of officers will assemble at the Springfield Armory, Springfield, Mass., on Saturday, March 11, 1893, for the purpose of testing and reporting upon such magazine rifles of American invention as may be presented. The arms to be tested must be presented to the Board at the Springfield Armory before March 31, 1893, and should be of caliber .30, so as to use the Government cartridges in making the tests, but the Board, in its discretion, may allow arms of other caliber to be presented, provided that acceptable ammunition for their test is furnished by the owners. For any further information address Capt. S. E. Blunt, recorder of the board, Springfield Armory, Springfield, Mass.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance, U. S. Army.

After examination, all this correspondence was approved by the board. Letters were received from M. H. Durst, New York, N. Y. (L. R., 54 and 56), submitting his guns and explaining the merits of their construction; from James L. Smith, Savannah, Ga. (L. R., 55), and Don D. Miles, Aurora, Ill. (L. R., 57), reporting their guns would not be ready for test; from the Adjutant-General of the Army (L. R., 58), with reference to the station of the members of the board while it is in session, and also the following letter from the Secretary of War:

WAR DEPARTMENT,
Washington, March 15, 1893.

SIR. General Orders No. 16, dated Adjutant-General's Office, March 1, 1893, detailing a board for the purpose of testing and reporting upon such rifles of American invention as may be presented for test, and stating that the arms submitted must be of .30 caliber, and must use the Frankford Arsenal experimental cartridge, is hereby amended so as to receive and test arms, irrespective of caliber, when in the opinion

of the board such tests may be deemed useful and for the best interests of the service, with the understanding that the ammunition (powder provisionally excepted) required for the test of any arm which is not adapted to the .30 caliber Frankford Arsenal experimental cartridge shall be furnished by the person presenting the arm for test.

It is not intended that the board shall consider the adoption of a rifle other than .30 caliber for our service, but the board may properly test arms of different caliber, having in view their adaptability to the construction of an arm of the standard caliber.

Respectfully,

DANIEL S. LAMONT,
Secretary of War.

Col. ELWELL S. OTIS,
President Board for Testing Magazine Rifles of American Invention,
Springfield Armory, Springfield Mass.

Telegrams (L. R., 60, 62, and 63) were received from Maj. W. R. Livermore, U. S. Army; Lieut. Cassius E. Gillette, U. S. Army; and M. H. Durst, Hartford, Conn., with reference to the guns they intended to bring before the Board.

Letters (Letter Book, pp. 88 to 92 inclusive) were sent to Don. D. Miles, Aurora, Ill.; the Lee Arms Company, South Windham, Conn.; L. F. Bruce, Springfield, Mass.; and John Van Patten, Lansingburg, N. Y.

The following guns were submitted to the board:

The Spencer-Lee magazine rifle, caliber .45 (No. 1 on list of guns), submitted by Francis Bannerman, New York, N. Y.

The Lee, Model 1893, caliber .30 (No. 2 on list of guns), submitted by J. P. Lee, Hartford, Conn.

The Savage, caliber .30 (No. 3 on list of guns), submitted by Arthur Savage, Utica, N. Y.

The Durst, Nos. 1 and 2, caliber .303 (Nos. 4 and 5 on list of guns), and Nos. 3 and 4, caliber .30 (Nos. 6 and 7 on list of guns), submitted by M. H. Durst, Wheatlands, Cal.

The Blake, caliber .30 (No. 8 on list of guns), submitted by J. H. Blake, New York, N. Y.

The Russell-Livermore, Nos. 1 and 2, caliber .303 (Nos. 9 and 10 on list of guns), and No. 3, caliber .30 (No. 11 on list of guns), submitted by Maj. W. R. Livermore, U. S. Army.

The White, caliber .30 (No. 12 on list of guns), submitted by Lieut. H. K. White, U. S. Marine Corps, for the White Magazine Rifle Company, Washington, D. C.

The Hampden magazine gun (No. 13 on list of guns), submitted by Mr. Allen Webster, Springfield, Mass., counsel for the inventor, T. B. Wilson, of East Boston, Mass.

Two models of magazine and breech action were offered by L. F. Bruce, Springfield, Mass.

Two drawings of a magazine and breech action were offered by John Van Patten, Lansingburg, N. Y.

The board, after discussion, decided that under the orders by which they were convoked, and the subsequent modifications thereof, they were empowered to receive only magazine rifles prepared for test, and that models and drawings could not be accepted.

Messrs. Bruce and Van Patten were therefore so informed (Letter Book, pp. 91 and 92), and the models and drawings returned.

The board then adjourned to meet on the 31st instant.

SPRINGFIELD ARMORY,
Springfield, Mass., March 31, 1893.

The board met pursuant to adjournment.

Present, all the members.

The following letter (L. R., 64) was received from Lieut. Gillette, U. S. Army:

SPRINGFIELD ARMORY, MASS.,
March 31, 1893.

SIR: I have the honor to report that I left Chicago with a gun to submit to the Board day before yesterday, in abundant time to reach Springfield at 10:30 p. m. yesterday, but owing to the train being delayed by a wreck I missed connections in New York, and had to take a later train, arriving at Springfield twenty-five minutes after midnight.

I would respectfully request to be allowed to present the gun to the board at its session to-day.

Very respectfully, your obedient servant,

CASSIUS E. GILLETTE,
First Lieut., U. S. Engineers.

Col. E. S. OTIS,
President of Board on Magazine Arms.

After consideration, the board decided that the arm referred to in the above communication be received, tested, and reported upon in accordance with the directions contained in the order by which the board was called, since Lieut. Gillette's failure to present the arm on the 30th instant was not due to his fault or neglect, but to accident for which he was entirely irresponsible.

The board then proceeded to the test of the White gun, the safety test and a portion of the first test for rapidity with accuracy, being fired with results as in the synopsis of tests. The gun was then withdrawn by Lieut. White (with the permission of the board) for repairs.

The test of the Savage gun was prosecuted, the safety test and the regular tests as far as to include a portion of the test for defective cartridges being concluded with results as in the synopsis of tests.

Mr. Savage then preferred a request to withdraw the arm for certain repairs, but after careful consideration the board concluded that from the extended tests already conducted and their observation of the performance of the arm and the action of its mechanism further tests were not necessary to enable them to arrive at a judgment of the relative merits and defects of the system.

Lieut. Cassius E. Gillette, U. S. Army, then presented his gun, in incomplete form, to the board and explained its mechanism from its completed parts and from drawings.

After consideration the board concluded that in consequence of its incomplete condition the arm was covered by the ruling of the board of the 30th instant with reference to models and drawings and consequently returned the parts of the gun and the drawings to Lieut. Gillette.

The board then adjourned to Monday, April 3.

SPRINGFIELD ARMORY,
Springfield, Mass., April 3, 1893.

The board met pursuant to adjournment.

Present, all the members.

Letters were received from M. H. Durst (L. R., 66) with reference to the gun known on the records of the board as Durst No. 4; from George Fogerty, Cambridgeport, Mass. (L. R., 67), reporting he had

not time to complete his gun, but submitting drawings thereof; from the Chaffee-Reece Arms Company, Washington, D. C. (L. R.. 68), submitting a Chaffee-Reece gun; from the commanding officer, Frankford Arsenal (L. R., 69), with reference to cartridges for the board; from George S. Bartlett, Anaconda, Mont. (L. R., 70), and A. J. Pocock, Dayton, Ohio (L. R., 72), reporting they could not have guns ready, but desiring to purchase caliber .30 barrels, and from J. H. Blake, New York, N. Y. (L. R., 71), requesting a later date than Wednesday, April 5, 1893, first assigned for the test of his gun.

In reply Mr. Fogerty was informed (Letter Book, p. 95) that the board, under their orders, could not receive drawings only, the actual gun being required for test.

With reference to the Chaffee-Reece gun the recorder stated that the letter above mentioned and the gun itself had been handed to him by a representative of the Chaffee-Reece Company, at 2 p. m. Saturday, April 1. The board, after discussion, thereupon directed that a letter be sent the Chaffee-Reece Company, inclosing a copy of the order convening the Board and calling attention to the paragraph requiring that "the arms to be tested must be presented to the board at the Springfield Armory before March 31, 1893," and expressing consequently the inability of the board to now receive the gun.

A letter (Letter Book, p. 96) was accordingly sent.

A letter (Letter Book, p. 101) was sent Mr. J. H. Blake, stating that no change could be made in the date assigned for tests of his gun.

Letters (Letter Book, pp. 99 and 100) were sent to George S. Bartlett and A. J. Pocock, advising them to prefer their request for the purchase of caliber .30 barrels to the commanding officer, Springfield Armory.

The board then proceeded to the test of the Durst guns Nos. 2 and 4 (Nos. 5 and 7 on list of guns submitted). A portion of the safety test of the latter and of the regular tests, to include a portion of the first test of the former, being concluded with results as in the synopsis of tests.

A letter (Letter Book, p. 98) was sent to Lieut. H. K. White, U. S. Marine Corps, asking if he would have his gun ready for test on Saturday, April 8, and a letter (Letter Book, p. 102) to Allen Webster, Springfield, Mass., designating Friday, April 7, for the test of the Hampden gun.

The board then adjourned to meet on the 4th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 4, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter (L. R., 73) was received from the commanding officer, Frankford Arsenal, with reference to cartridges sold inventors, and a telegram (Letter Book, p. 103) sent that officer.

The board then proceeded to the test of the Durst No. 3, the safety test, and the regular tests as far as to include the first portion of the endurance test being conducted with results as in the synopsis of tests.

The board then adjourned to meet on the 5th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 5, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter (L. R., 74) was received from John F. Alexander, agent for the Chaffee-Reece Arms Company, requesting the return to him of the gun he had brought to the board, and the gun was accordingly delivered.

A letter (L. R., 75) was received from Allen Webster, attorney for the Hampden gun, and a telegram (L. R., 76) from John H. Blake, reporting their guns would not be ready for test at the dates previously designated.

The board then proceeded to the test of the Russell-Livermore guns Nos. 1 and 2, the safety tests and a portion of the regular tests of each being conducted with results as in the synopsis of tests.

The board then adjourned to the 6th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 6, 1893.

The board met pursuant to adjournment.

Present, all the members.

Letters were received from the commanding officer, Frankford Arsenal (L. R., 77 and 78), with reference to cartridges for the board; from the Adjutant-General of the Army (L. R., 79), stating that under the law guns could not be received by this board for test after March 30; from J. H. Blake, New York, N. Y. (L. R., 80), explaining why he had not appeared for the test of his gun upon the day agreed upon with the board; from Lieut. H. K. White, U. S. Marine Corps (L. R., 82), reporting his gun would not be ready for test upon the 8th instant as designated by the board, and suggesting the 11th instant for the test; and from J. P. Lee, Hartford, Conn. (L. R., 81), with reference to the gun he submitted for trial.

Letters and telegrams (Letter Book, pp. 106 to 108) were sent to J. H. Blake, designating Saturday, the 8th instant, for the test of his gun; to Lieut. H. K. White, U. S. Marine Corps, designating Tuesday, the 11th, for the test of his gun, and to Browning Bros., Ogden, Utah, communicating the decision of the War Department with reference to the time during which guns could be received by the board.

The board then proceeded to the test of the Lee gun, model 1893 (No. 2 on list of guns before the board), the safety tests and the regular tests as far as to include the dust test being conducted with results as in the synopsis of tests.

The board then adjourned to the 7th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 7, 1893.

The board met pursuant to adjournment.

Present, all the members.

A telegram (L. R., 83) was received from J. H. Blake, New York, stating he would have his gun ready for test upon the 8th instant; and a letter from Irving Boardman, Elmira, N. Y. (L. R., 84), making inquiries as to the time within which arms could be received; to the latter a reply (Letter Book, p. 109) was sent.

The board then proceeded to examine the Spencer-Lee gun (No. 1 on list of arms before the board), and subsequently to the continuation of the test of the Durst No. 3 (No. 6 on list of guns before the board), the latter portion of the endurance test, the dust tests, and a portion of the tests with excessive charges being conducted with results as in the synopsis of tests.

After conferences with Mr. Durst as to the dates when his guns Nos. 1, 2, and 4 could be provided with suitable ammunition for their test, the board designated Tuesday, the 18th instant, for commencing such trials.

The board then adjourned to the 8th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 8, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter was received from Lieut. H. K. White, U. S. Marine Corps (L. R., 85), reporting he expected to have his gun ready to continue test on Monday, the 10th instant, and a telegram (Letter Book, p. 111) was accordingly sent him designating that day for the purpose.

The test of the Blake gun (No. 8 on list of guns before the board) was then commenced, the safety test and so much of the regular tests as to include those for rapidity with accuracy being conducted with results as in the synopsis of tests.

The board then adjourned to the 10th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 10, 1893.

The board met pursuant to adjournment.

Present, all the members.

Letters were received from M. H. Durst (L. R., 86 and 87) desiring that the Durst gun No. 1 be sent him and requesting that a caliber .30 barrel be sold him; and a letter from Allen Webster, Springfield, Mass. (L. R., 88), stating the improvements on the Hampden gun were not completed, but if finished in season he would submit it.

A reply to each of these communications was sent (Letter Book, pp. 112 to 115).

The test of the Russell-Livermore No. 3 (No. 11 on list of guns before the board) was then commenced, the safety test and the first portion of the regular tests being conducted, with results as in the synopsis of tests.

The repairs to the White gun having been concluded the arm was again brought before the board by the inventor, the regular tests resumed and continued to include a portion of the test with excessive charges, with results as in the synopsis of tests.

The board then adjourned to the 11th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., April 11, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter was received from John H. Blake, New York (L. R., 89), with

reference to further trials of his gun, and a reply (Letter Book, p. 117) sent.

The board then resumed the trial of the Russell-Livermore No. 3 (in the presence of Maj. Livermore), the tests for rapidity with accuracy and rapidity at will being concluded, with results as in the synopsis of tests.

There being no other guns awaiting trial, and Mr. Durst having reported that the ammunition for his guns Nos. 1, 2, and 4 would not be received and the guns fully adjusted to it before the 18th instant, the board adjourned to that date.

SPRINGFIELD ARMORY,
Springfield, Mass., April 18, 1893.

The board met pursuant to adjournment.

Present, all the members.

The recorder laid before the board the communications received by him since the last adjournment. These included letters from M. H. Durst, New York, N. Y. (L. R., 93 and 95), with reference to barrels and ammunition for his guns and (L. R., 99) reporting he would not be ready to proceed with the tests of his guns on April 18, the date previously designated by the board.

From Allen Webster, Springfield, Mass. (L. R., 96), stating that neither himself nor Mr. Wilson, the inventor of the Hampden gun, would appear before the board at their session of April 18.

Letters (L. R., 94 and 100) from A. F. De Lecroix, Chicago, Ill., with reference to a Belgian rifle that he wished to submit to the board.

A telegram from the Board of Ordnance and Fortification (L. R., 97) inquiring as to the probable date of receipt of Magazine Gun Board report.

From T. E. Miller, Boston, Mass. (L. R., 98), with reference to a detachable magazine of his invention for single-loading rifles and the following letter from the Secretary of War:

WAR DEPARTMENT,
Washington, April 7, 1893.

SIR: Referring to the clause in General Orders, No. 16, Adjutant-General's Office, 1893, which requires "that arms to be tested must be presented to the board, etc., before March 31, 1893," your board is authorized and instructed to receive and examine magazine arms of American invention which conform to the other requirements communicated to your board, that may be presented after March 31 and before May 1, 1893. If on examination the board finds any of the arms presented after March 31 to have sufficient merit to warrant the expense of a trial, the board will make such tests and report upon these arms (those presented after March 31) as the board has time for without delaying its report or encroaching upon the time required for a full test and investigation of the arms presented before March 31.

It is now desired that your report should reach this office not later than June 15, 1893.

Respectfully,

DANIEL S. LAMONT,
Secretary of War.

Col. ELWELL S. OTIS,
President of the Board for Testing and Reporting on Magazine Rifles of American Invention, appointed by G. O. 16, A. G. O., 1893, Springfield Armory, Springfield, Mass.

The replies of the recorder (Letter Book, pp. 119 to 134 inclusive) to these communications were also submitted.

After examination all this correspondence was approved by the board.

Letters were received from J. P. Lee, Hartford, Conn. (L. R., 102),

and John H. Blake, New York (L. R., 103), requesting return of their guns: and from Lieut. Cassius E. Gillette, U. S. Army (L. R., 104), desiring firing pins for an arm he proposed to submit. Replies (Letter Book, pp. 135 to 138) to these communications were sent.

There being no guns on hand awaiting trial, and no prospect of any being received before May 1, the board then adjourned to that date.

SPRINGFIELD ARMORY,
Springfield, Mass., May 1, 1893.

The board met pursuant to adjournment.

Present, Col. Otis, Lieut. Cols. Hall and Farley, Maj. Freeman, and Capt. Blunt; absent, Capt. Anderson.

The following order was received from the War Department:

GENERAL ORDERS, No. 33.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, April 25, 1893.

By direction of the Secretary of War, Lieut. Col. Joseph P. Farley, Ordnance Department, and Capt. George S. Anderson, Sixth Cavalry, whose services can no longer be spared from their commands and stations without detriment to the service, are relieved from duty as members of the board of officers convened at Springfield Armory, Springfield, Mass., by General Orders, No. 16, March 1, 1893, from this office, for the purpose of testing and reporting upon magazine rifles of American invention, to take effect upon the arrival of their successors, and Col. John C. Bates, Second Infantry, and Maj. Francis Moore, Fifth Cavalry, are detailed as members of the board in their places, and will, at once, report in person at Springfield for duty accordingly.

Lieut. Col. Farley and Capt. Anderson, on being thus relieved, will proceed to join their proper stations.

The travel enjoined is necessary for the public service.

By command of Maj. Gen. Schofield:

R. WILLIAMS,
Adjutant-General.

Official:
H. C. CORBIN,
Assistant Adjutant-General.

The recorder laid before the board the communications received by him since the last adjournment.

These included letters from Lieut. H. K. White, U. S. Marine Corps (L. R., 105), desiring to withdraw his gun for repairs; M. H. Durst, New York, N. Y. (L. R., 108, 110, and 113), with reference to barrels and cartridges for his guns; John H. Blake, New York, N. Y. (L. R., 114), inquiring if guns could be submitted up to May 1; Francis Bannerman, New York, N. Y. (L. R., 112 and 118), inquiring with reference to the test of the Spencer-Lee gun he had submitted; from Allen Webster, Springfield, Mass., and T. B. Wilson, East Boston, Mass. (L. R., 116 and 121), with reference to the Hampden gun; from J. C. Hunter, San Francisco, Cal. (L. R., 111), with reference to his detachable magazine; from Emil Dreher and Thomas A. Murphy, Newark, N. J. (L. R., 117 and 119), with reference to drawings of a magazine rifle of the former's invention; from the commanding officer, Frankford Arsenal (L. R., 109), with reference to cartridges for the Durst gun; and from the Parker Gun Company, Meriden, Conn. (L. R., 115), inquiring as to the experience of the board with reference to piercing of primers.

The replies of the recorder (Letter Book, pp. 140 to 157, inclusive) to these communications were also submitted.

After examination all this correspondence was approved by the board.

Letters were received from John H. Blake, New York (L. R., 122),

and M. H. Durst, New York (L. R., 123), with reference to their guns and replies (Letter Book, pp. 159 and 164) sent.

A letter (L. R., 125) was received from J. H. Hanson, Crystal Falls, Mich., and reply (Letter Book, p. 161) sent.

A letter (Letter Book, p. 163) was sent Francis Bannerman, New York, with reference to the Spencer-Lee gun.

A letter (Letter Book, p. 158) was sent T. B. Wilson, East Boston, Mass., designating May 10 for the test of the Hampden gun.

A letter (L. R., 126) was received from the commanding officer, Springfield Armory, with reference to ammunition for the board.

There being no guns expected for test before the 5th instant, the board then adjourned to that day.

SPRINGFIELD ARMORY,
Springfield, Mass., May 5, 1893.

The board met pursuant to adjournment.

Present, Cols. Otis and Bates, Lieut. Col. Hall, Majs. Freeman and Moore, and Capt. Blunt.

Col. Bates and Maj. Moore relieving Lieut. Col. Farley and Capt. Anderson in accordance with General Orders, No. 33, Headquarters of the Army, Adjutant-General's Office, April 25, 1893.

The recorder laid before the board the communications received by him since the last adjournment.

These included letters from John H. Blake, New York, N. Y. (L. R.,. 127), with reference to his rifle and requesting its return; and from M H. Durst, New York, N. Y. (L. R., 128), requesting a diminution of the powder charge used by the board in their tests with excessive charges and that the board determine for him the pressures produced in his cartridge shells by various charges.

The replies of the recorder (Letter Book, pp. 165 to 168, inclusive) were also submitted.

After examination all this correspondence was approved by the board.

A telegram was received from M. H. Durst, New York (L. R., 129), reporting he was not ready to continue the tests of his guns and requesting further delay until the 11th instant.

Letters were received from Mark T. Burns, Atlantic City, Wyo. (L. R., 130), making various inquiries with reference to magazine guns; and from the commanding officer, Frankford Arsenal (L. R., 131), with reference to cartridges for the Durst guns.

Replies (Letter Book, pp. 169 to 173, inclusive) were sent to Mr. Blake and Mr. Burns, and to Mr. Durst, designating Thursday, the 11th instant, for resuming the tests of his guns and referring him to the Chief of Ordnance, U. S. Army, with reference to the experiments he desired to have conducted.

There being no guns on hand for test and none expected before the 10th instant, the board then adjourned to that day.

SPRINGFIELD ARMORY,
Springfield, Mass., May 10, 1893.

The board met pursuant to adjournment.

Present, all the members.

The recorder laid before the board the communications received by him since the last adjournment. These included letters from John H.

Blake, New York (L. R., 132, 136, and 137), renewing his request for the temporary return of his gun; from Arthur Savage, Bridgeport, Conn. (L. R., 134), requesting return of his gun; and from George S. Putnam, Paris, France (L. R., 135), making various inquiries.

The replies of the recorder (Letter Book, pp. 176 to 179, inclusive) were also submitted.

After examination all this correspondence was approved by the board.

Mr. Thomas B. Wilson, of East Boston, Mass., and Mr. C. E. Billings, of Hartford, Conn., appeared before the board with the Hampden gun, in which they were interested.

The tests of this gun (which had been previously submitted to the board) were then begun and continued to include all of the regular tests, with results as in the synopsis of tests.

The board then adjourned to meet on the 11th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., May 11, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter (L. R., 138) was received from Rochfort and Stayton, New York, N. Y., attorneys for the Durst Gun Syndicate, stating that for reasons which had been laid before the Secretary of War they could not submit for test or consent to further trials of the Durst guns until action had been taken by the Department.

There being no other arms awaiting trial, the board proceeded to a discussion of the merits and defects of the different systems they had examined, and subsequently adjourned to the 12th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., May 12, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter was received from Webner E. Loomis, Springfield, Ill. R., 139), making various inquiries, and reply (Letter Book, p. 183) sent.

The board then proceeded to a further consideration of the tests of guns that had been submitted and to the preparation of their report, and subsequently adjourned to the 13th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., May 13, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter was received from F. W. Griswold, Providence, R. I. (L. R., 140), making various inquiries, and reply (Letter Book, p. 184) sent.

The board then resumed consideration of the tests of guns that had been submitted and the preparation of their report, and subsequently adjourned to the 15th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., May 15, 1893.

The board met pursuant to adjournment.

Present, all the members.

Consideration of the tests of guns and the preparation of their

report was resumed. After agreeing upon the latter, to afford time for its final preparation and signature, the board adjourned to the 16th instant.

SPRINGFIELD ARMORY,
Springfield, Mass., May 16, 1893.

The board met pursuant to adjournment.

Present, all the members.

A letter (Letter Book, p. 185) was addressed to the commanding officer, Springfield Armory, informing him of the proposed adjournment of the board and requesting him to assume custody of the arms then in their possession.

A letter (Letter Book, p. 187) was addressed to the Board of Ordnance and Fortification informing them of this action.

A letter (Letter Book, p. 202) was addressed to the Adjutant-General of the Army, informing him that the report of the board was on this date forwarded to the Board of Ordnance and Fortification.

A letter (L. R., 141) was received from the commanding officer, Springfield Armory, accepting custody of the arms that had been before the board.

The completed report of the board having been examined and found correct, the members affixed their signatures and the report was forwarded to the Board of Ordnance and Fortification.

The board then adjourned without day.

ELWELL S. OTIS,
Colonel, Twentieth Infantry.
J. C. BATES,
Colonel, Second Infantry.
ROBT. H. HALL,
Lieutenant-Colonel, Sixth Infantry.
H. B. FREEMAN,
Major, Sixteenth Infantry.
FRANCIS MOORE,
Major, Fifth Cavalry.
STANHOPE E. BLUNT,
Captain, Ordnance Department.

List of guns submitted with exhibitor's address.

No.	Name of gun.	Exhibitor's address.
	Submitted before Mar. 31, 1893:	
1	Spencer-Lee	Francis Bannerman, 27 Front street, New York.
2	Lee, model 1893	J. P. Lee, Hartford, Conn.
3	Savage	Arthur Savage, Utica, N. Y.
4	Durst, No. 1	M. H. Durst, Wheatland, Cal.
5	Durst, No. 2	Do.
6	Durst, No. 3	Do.
7	Durst, No. 4	Do.
8	Blake, No. 1	John H. Blake, 136 Liberty street, New York.
9	Russell-Livermore, No. 1	Maj. W. R. Livermore, Corps of Engineers, U. S. Army.
10	Russell-Livermore, No. 2	Do.
11	Russell-Livermore, No. 3	Do.
12	White	Lieut. H. K. White, U. S. Marine Corps.
13	Hampden	T. B. Wilson, 36 New street, East Boston, Mass.
	Submitted after Mar. 31 and before May 1, 1893:	
14	Blake, No. 2	John H. Blake, 136 Liberty street, New York.

PART II.—*Descriptions of the magazine arms before the board.*

No. 1.—SPENCER-LEE.

(Plate I.)

This gun, which was tested by the Board on Magazine Guns of 1882, is described as follows in their report. (See Report of the Chief of Ordnance for 1882, Appendix 30.)

The gun is shown in section, breech opened and closed, and largely in detail in the plate.

The breechblock A, Figs. 1 and 2, is supported against the pressure of the gas, when the piece is fired, by the recoil block B, solid with the guard, which has a circular recess concentric with the rear of the breechblock. The latter is slipped in the recess sideways and has, when assembled, a motion of rotation in a vertical plane. The recoil block is in turn supported by the rear of the receiver, as seen in Figs. 1 and 2.

The trigger C, Fig. 21, and hammer D, Fig. 17, are pivoted in the guard plate, the nose of the former, or the sear, being held in position in the notch of the latter by the sear spring E, Figs. 1, 2, and 3.

The mainspring F is connected with the hammer and the under rear of the breechblock by the swivels G and H, Figs. 1 and 2.

The piece is shown cocked in Fig. 2, the firing pin being seen at J.

When the trigger is pulled the head of the firing pin is struck by the upper end, K, of the hammer.

The breech block is operated by a cam pin C, Fig. 1, with friction roller on the inside of the rear end on the left of two sliding bars, L, connected by the hand grasp M, Fig. 2. The cam pin travels in a groove on the left side of the breechblock. The groove has a frog or switch, N, Figs. 3 and 11, pivoted near its rear. When the cam pin enters the groove, as it does when the forked slide is forced to the rear, it rolls over the incline O of the frog.

The pin can not rise, since the bars of the slide travel in grooves on the inside of the receiver. Hence the frog must be pressed downward and its point, in turn pressing on the bottom of the groove in the block, compels the latter to descend.

When the pin passes out of the groove to the rear, the front of the breechblock would rise above the receiver under the pressure of the mainspring, if not held down by the extractor, as explained later on.

When the slide is returned to its first position the cam pin travels on the lower side of the groove, the frog turning freely about its pivot, and the front of the block is forced to descend to the level of the chamber.

The extractor, Fig. 7, is pivoted in the slot P, Fig. 2, in the right branch of the slide, as seen at Q, Fig. 4. When the slide is carried to the rear the free end of the extractor passes on the inside of the receiver in the groove in which the slide works, and its hook, R, pushes the shell to the rear. Before, however, the extractor reaches the shell the block will have begun to fall, and the lever S, of the shell-starter, Figs. 1, 2, and 9, being struck by the right branch of the slide, will

have so loosened the shell that the extractor has merely to push it out of the chamber into the upper surface of the block. When the extractor has passed beyond the shoulder T, Fig. 4, in its rearward motion, the breechblock, under the pressure of the mainspring, will fly up and eject the empty shell. If the block be operated quickly the shell will be ejected by riding up the incline at its rear.

The piece is cocked in the act of opening the breechblock by the cam pin coming in contact with the hammer and pressing it back until the nose of the sear enters the notch. At the front of the breechblock is a movable face or head U, Figs. 1, 2, and 12, which is forced against the base of the cartridge during the closing of the breech. On the opening of the latter the head drops away and thus facilitates extraction of the shells. The head is operated by the shaft V, Figs. 1, 2, and 3. The shaft is in turn operated by the cam pin, in its passage through the groove coming in contact with its arm or lever W, Figs. 3 and 19.

When the pin first enters the groove it strikes on the face X of the lever and rotates the shaft until its flat side is parallel to the face of the block, Fig. 3. The head can then drop back against the body of the block, as in Fig. 1. When the cam pin is returned to its first position it travels the lower part of the groove, raises the frog, and strikes against the face Y of the lever W and rotates the shaft to the position shown in Fig. 2, its edge forcing the face of the block against the cartridge.

A device for locking the hammer until the breechblock is closed is shown in Fig. 16 and at Z, Fig. 3. It is interposed between the head of the hammer and a shoulder D′ on the shaft V. The closing of the breechblock rotates the shaft and withdraws the shoulder from the front of the locking bar.

The latter is then free to move to the front to the extent permitted by the recess in which the tenon on the bar enters, and the hammer can fall if the trigger is pulled.

The cartridges, when the piece is used as a magazine gun or single-loader, are drawn forward into the chamber of the arm A of the extractor.

The magazine is that known as the Lee, with very slight modification. It is attached to the under side of the breechblock and rises and falls with it. The breechblock is recessed on its under side sufficiently to receive a single cartridge. When this one is drawn forward into the chamber another from the magazine takes its place in the block. It will be seen, then, that the complete backward motion of the slide causes the block to descend, the shell to be pushed out on its upper surface, and then the block to fly up and eject the empty shell; the forward motion then carries a cartridge from the magazine into the chamber and causes the block to descend to its proper position in rear of it.

A cut-off, Fig. 24, may be so turned as at B′, Fig. 3, to limit the backward motion of the slide, thus preventing the extractor passing beyond the shoulder T. The block then can not rise and bring the cartridges from the magazine opposite the chamber.

The piece may consequently be used as a single-loader. If the cut-off be turned vertically downward the piece may be used as a magazine arm. If turned upward to its furthest extent, a small pin, E′, Figs. 3 and 24, on its under side will enter a notch in the slide and lock it and, therefore, the breechblock.

Three motions are necessary to operate this piece as a magazine gun, viz, the movement of the slide to the rear, to the front, and the pulling of the trigger; in addition, when used as a single-loader, loading.

No. 2.—LEE, MODEL 1893.

(Plate II.)

Description and plate omitted.—Confidential.

No. 3.—SAVAGE.

(Plate III.)

This arm was brought before the board by Mr. Arthur Savage, of Utica, N. Y.

The magazine, cylindrical in shape, lies below the receiver. Its full capacity is 9 cartridges. There is no cut-off, but firing the upper cartridge from the magazine, replacing it, and so on, a single-loader fire with 8 cartridges in reserve can be maintained.

In the plate Fig. 1 shows the action open; Fig. 2 the action closed.

Fig. 3 is a cross section of the magazine on AA, Fig. 1.

Figs. 4 and 5, cross section and side view of the magazine-carrier.

Fig. 6, views of the magazine spring and spindle.

Fig. 7, a rear view of the breechblock.

Fig. 8, a side view of the magazine regulator and stop.

Fig. 9, three views of loading packet.

DESCRIPTION.

The mechanism is operated by the handle bar (*h*, Figs. 1 and 2), pivoted to the trigger guard (*g*, Figs. 1 and 2), and by the guide lever (*k*, Figs. 1 and 2), which passes within the casing and between the faces (*a*, Fig. 7) at the rear of the breechblock. On the interior of the left face of the block is a channel (*a*, *b*, Figs. 1 and 2), through which a lug (*a*, Figs. 1 and 2) at the end of the guide lever operates. In one piece with the block is the breech bolt (*m*, Fig. 1), containing the mainspring and firing pin and striker (*n*, Fig. 2).

The trigger (*t*, Figs. 1 and 2) is slotted at one end to embrace the stud (*s*, Fig. 1) on the rear. A shoulder (*c*, Fig. 1), on the block serves as a cocking piece and engages against a corresponding shoulder (*c*, Fig. 2) on the sear.

The sear is secured to the breech casing by the pivot (*w*, Fig. 1).

The extractor (*m*, Figs. 2 and 7) lies in a dovetailed groove on the upper surface of the breech bolt, to which it is secured by a pin (*p*, Fig. 2). The heel (*d*, Fig. 1) of the regulator acts as an ejector.

The magazine consists of a hollow spindle (Fig. 6; *d*, Fig. 2), which lies within the carrier (Figs. 4 and 5), the ends of the carrier serving as journals, which turn over the spindle.

Notches on the forward end of the spindle (*a*, Fig. 6) and a spring catch on the breech casing prevent movement of the spindle. The rear end of the spindle (*e*, Figs. 1 and 6) passes through and is supported by the breech casing. The magazine spring is fastened at one end (*b*, Fig. 6) to the spindle, at the other (*c*, Figs. 5 and 6) to the carrier; when given an initial tension it then tends to cause the carrier to revolve around the spindle. Around the carrier are two sets of teeth (*n*, Figs. 1, 4, and 5) which, taken in pairs, form grooves to contain the cartridges. The last of these pairs of teeth are made higher and are joined by a plate (*a*, Figs. 3, 4, and 5) to prevent cartridges falling back into the magazine as it is being emptied.

The automatic regulator (Fig. 8; *d*, Fig. 1) by which the passage of cartridges from the magazine to the receiver is controlled, lies in a recess in the left face of the receiver, its projecting arm (*a*, Fig. 8), engaging over the shaft (*e*, Fig. 1) of the spindle, its lug (*e*, Figs. 2 and 8) closing the mouth of the magazine.

Chargers made of tin, holding six cartridges, are used to facilitate the loading of the magazine.

The lip (*a*, Fig. 9) engages in the front portion of the receiver, near the breech casing, while the rib (*b*, Fig. 9) rests at the rear against the shoulder formed by the left wall of the receiver and the automatic regulator. Pressing down upon the cartridges they can then be stripped into the magazine. The charger is then removed.

Presuming the piece to have been fired, the subsequent action is as follows:

Depressing the handle causes the guide lever (*k*, Fig. 2) and its lug (*a*, Fig. 2) to traverse the channel (*a*, Fig. 7) between the faces of the breechblock, first lowering and freeing the bolt from the recoil shoulders (*f*, Figs. 1 and 2) and then drawing the block and bolt to the rear, extracting the empty shell, and when its head reaches the shoulder (*d*, Figs. 1 and 8) on the regulator ejecting it. When the bolt is entirely back the spiral spring (*p*, Figs. 1, 3, and 8) back of the regulator throws it forward, depressing the stop (*e*, Figs. 2 and 8) and permitting the upper cartridge in the magazine (*b*, Fig. 3) to rise slightly in front of the bolt. Raising the handle throws the breechblock and bolt forward, and when the edge (*l*, Fig. 1) begins to bear in the channel between the faces of the block raises the bolt up in front of the locking shoulders. In this movement, after the shoulder (*c*, Figs. 1 and 7) abuts against the nose (*c*, Fig. 2) of the sear, compression of the mainspring takes place. As the bolt pushes the cartridge into the chamber it also seats the regulator (*d p*, Fig. 1) in its recess in the receiver, causing the stop (*e*, Figs. 2 and 8) to rise and preventing the passage of a second cartridge from the magazine.

No. 4—DURST No. 1.

(Plate IV.)

This arm was submitted to the board by Mr. M. H. Durst, of Wheatland, Cal. Its magazine, cylindrical in shape and having a capacity of ten cartridges, lies directly below the receiver. It can be loaded with single cartridges or they can be stripped from a clip. The gun has a cut-off.

In the plate Fig. 1 shows a longitudinal section of bolt and magazine with action open; Fig. 2 the same with action closed.

Fig. 3 is a rear view and Fig. 5 a right-hand side view of the bolt body.

Fig. 4, views of the right side, the bottom, and the front end of the cocking piece.

Fig. 6, views of the right side and front end of the bolthead.

Fig. 7, the firing pin.

Fig. 8, the rear, the side, and the front of the firing-pin nut.

Fig. 9, the mainsprings.

Figs. 10 and 11, longitudinal sections, showing right and left inner faces, respectively, of the receiver.

Fig. 12, the trigger, sear, ejector, and sear and ejector spring plate.

Figs. 13 and 14, sections of the magazine on AA, Fig. 1, showing respectively the magazine turned on and the magazine cut off.

Fig. 15, front view of the receiver and breech casing.

Fig. 16, front view of the magazine proper.

Fig. 17, magazine assembling screw.

Fig. 18, cut-off.

Fig. 19, magazine spindle.

Fig. 20, magazine spring and follower.

DESCRIPTION.

The barrel is of the English standard caliber .303, and chambered for a cartridge similar to that of the Lee-Speed of England, except that it has a cannelured instead of a flanged head.

The stock is in two parts, connected by the upper and lower parts of the receiver and magazine casing (or shoe) and the trigger guard.

The side walls of the receiver immediately below the plane of the lower surfaces, supporting and guiding the bolt in its travel, spread out to the right and left (*b b*, Figs. 10, 11, 13, and 15), forming the upper portion of the shoe or magazine box. Above the box the left wall (*a c*, Figs. 1, 11, and 13) rises above and partly encircles the bolt, having on its face a channel (*a*, Figs. 1, 11, 13, and 15) for the passage of the left extractor, a cut (*d*, Figs. 1 and 11) for the heel of this extractor when removing the bolthead to dismount the mechanism, and a shoulder (*s*, Fig. 11) against which this heel, then acting as a bolt stop, abuts when the bolt is fully drawn back, as in Fig. 1. The end of the left wall is curved (*f*, Fig. 11), forming a cam for the corresponding surface on the base of the bolt handle (*f*, Fig. 5).

At the rear the tang (*h*, Figs. 2, 10, and 11) forms a channel, in which the cocking piece (Fig. 4) turns as the bolt handle is turned and along which it moves when the sear is released. The right wall (*d*, Fig. 13) of the receiver is cut away to afford space for the locking rib (*a b*, Fig. 5) when in the closed position. Back of the locking shoulder (*d*, Fig. 10) the right wall rises to the level of the left, having on its inner face a long cam way (*c*, Fig. 10) to operate the stud (*c*, Fig. 6) and release the hold of the second extractor (*f*, Fig. 6) upon the cartridge head. Between the two walls the floor of the receiver is cut away (*e*, Fig. 13) to permit passage of cartridges to and from the magazine. The ramp (*r*, Figs. 10 and 11) guides the point of the bullet into the chamber as the bolt is moved forward. In the breech casing, forward of the receiver space proper, is a channel on the right (*e*, Figs. 10 and 15) for the right extractor (*e*, Fig. 6) and on the left (*a*, Figs. 11 and 15) for the left extractor (*f*, Fig. 6).

In the floor of the tang are cuts for the ejector and the sear.

Under the front of the receiver and in the corresponding portion of the barrel over the chamber is a mortise for the cartridge stop (*k*, Figs. 1 and 2).

The bolt is composed of the body, head, cocking piece, firing pin, and nut, and the mainsprings. The central part of the body (*v w*, Figs 2 and 5) is bored of one dimension for the movement of the firing pin and its collar, contracted (*w*, Figs. 2 and 3) for the passage of the pin only and to afford a shoulder for the rear bearing of the mainsprings. Farther back (*v f*, Fig. 5; *b n*, Fig. 3) half of the right and of the lower side of the bolt is removed to form a channel for the movement of the forward half (*a b*, Fig. 4) of the cocking piece. At the rear the base of the handle is extended and forms partly, as a collar, the cam (*f*, Figs. 3 and 5) which induces the bolt's rotation.

On the upper surface is the locking rib (*a*, Fig. 3; *a b*, Fig. 5) having on the lower side of its projecting arm a channel (*m*, Fig. 5) which engages over the studs (*m*, Figs. 1 and 6) on the bolthead when drawing the bolt to the rear. The shoulder (*a*, Fig. 5) operates the extractor locking stud (*c*, Fig. 6) as the bolt is closed to the firing position. The bolthead is encircled near the rear by a collar (*m p*, Fig. 6) which carries the two extractors (*e* and *f*, Fig. 6); at the rear is a shank which engages in the well (*v*, Fig. 5) of the bolt body; on either side of this shank is a recess (*a*, Fig. 6) into which the projections (*b*, Fig. 7) on the collar of the firing pin turn as the bolt handle is revolved. Around the head, back of the extractors, is a channel with undercut sides in which the rotating wedge (*w*, Figs. 1 and 6) attached to the stud (*c*, Fig. 6) moves. On the underside a groove (*n*, Fig. 6) permits the action of the ejector. This groove is prolonged back on the bolt body (*n*, Fig. 1 and 3), and extending up onto its side (*n*, Fig. 5) affords clearance to the ejector as the handle is turned down.

The cocking piece (Fig. 4) moves along the channel (*f*, Fig. 5) in the rear of the body and rotates with the bolt. On its under side are the full-cock notch (*c*, Figs. 2 and 4), the half-cock notch (*e*, Figs. 2 and 4), and a long sloping notch (*f*, Figs. 2 and 4) into which the nose of the sear (*s*, Fig. 2) rises when the trigger is released after discharge and through which it moves when the handle, carrying with it the bolt body and cocking piece, is revolved. The front part of the well of the cocking piece is elongated (*d*, Fig. 4) for the reception of the shoulders (*a*, Fig. 7) of the firing pin.

The mainsprings (Fig. 9) engage (*b*, Fig. 1) over the central part (*a b*, Fig. 7) of the firing pin, bearing at the rear against the bottom (*w*, Fig. 2) of the bolt body and at the front against the shoulders (*b* and *c*, Fig. 7) on the pin. The shoulders (*a*, Fig. 7) on the pin engaging in the cut (*d*, Fig. 4) of the cocking piece compel the simultaneous rotation of pin and cocking piece.

The firing-pin nut (Fig. 8) entering at the rear the well of the cocking piece (*h*, Figs. 1 and 4) screws over the end of the firing pin. It is held secure by the tension of the mainspring.

The sear is assembled with the ejector. The sear spring (*t*, Fig. 2) bears at one end upon the guard bow, upon the other against a plate (*n*, Figs. 2 and 12), which distributes the tension upon both the sear (*s*, Figs. 1, 2, and 12) and the ejector (*e*, Figs. 1 and 12).

The outer walls of the magazine casing are made by the extensions (*b b*, Figs. 10, 11, and 13) of the outer faces of the receiver and by a corresponding shoe (*l*, Figs. 1 and 14), made in one piece with the trigger guard (*g*, Fig. 1). In the ends of the conical space thus made are circular openings serving as beds for trunnions at the front (*a b*, Fig. 16) and the rear of the inner conical box (*f*, *c*, *n*, Fig. 14), which is the actual magazine of the gun. As a core within this latter box is the spindle (*b*, Figs. 2 and 19) rising from a base (*c c*, Fig. 19; *p*, Fig. 2), which forms, when assembled, the rear end of the magazine. The magazine spring (Fig. 20), when unwound about 10 feet long, is coiled round the spindle, one end inserted in the hole (*a*, Fig. 19), the other secured to the follower (*a b*, Fig. 20). It is extended along the follower and finally terminates in a ring (*c d*, Fig. 20) which encircles the front of the spindle.

The ends (*a b*, Fig. 18) of the cut-off lever engage in recesses (*a b*, Fig. 16) in the front face of the magazine; the lever is retained in place by a hollow set screw (Fig. 17; *d*, Fig. 2). The sides of the box can be turned about the central spindle, thus winding up the magazine spring to any desired degree of tension.

The magazine is cut off by revolving it, by the projecting thumb piece (*d*, Fig. 18), within the outer casing or shoe, so that the cartridge passage (*e*, Fig. 16, also *e*, Figs. 13 and 14) passes from below the opening in the bottom of the receiver (*e*, Fig. 13), over to the right, as in *e*, Fig. 14. The bottom of the receiver will then be closed by the wall (*n*, Fig. 14) of the magazine. The magazine is retained in either position by the stud (*n*, Fig. 18) at the end of the cut-off lever spring (*n m*, Fig. 18), engaging in the recesses (*f n*, Fig. 15) at the end of the receiver.

Presuming the gun to have been fired the operations to remove the empty shell, reload, and fire are as follows:

On the first upward motion of the handle, in consequence of the connection of the bolt body, the cocking piece, and firing pin, all three turn, while the guide or bolt stop (*b*, Fig. 6), at the base of the left extractor, lying in the guide channel (*a*, Figs. 1, 11, and 13), prevents any rotation of the bolthead. As the pin turns the projections (*b*, Fig. 7) on its collar, moving along the sides of the recesses (*a*, Fig. 6) at the base of the bolthead shank, cam back the pin from the primer; this motion of the firing pin continues during the entire upward turn of the handle. After about one-third of the handle's rotation the cam on its base (*f*, Fig. 5) comes into bearing against the cam (*f*, Fig. 11) on the rear of the left wall of the receiver and moves to the rear the bodyof the bolt, and as the projecting arm (*m*, Fig. 5) has engaged over the studs (*m*, Figs. 1 and 6), on the bolthead, bringing back also the head and starting the empty shell.

Drawing then the bolt straight to the rear no other movement of the parts occurs until the stud (*c*, Fig. 6) enters the long cam (*c*, Fig. 10) in the right wall of the receiver, thus moving the wedge (*w*, Fig. 6) around the bolthead and under the left extractor, lifting it and freeing that side of the cartridge head. In the mean time, as the cut (*n*, Figs. 1 and 6) in the bolt body and head deepens, the ejector rises (*e*, Fig. 1) and stops further retraction of the cartridge shell, which is thus thrown out. Final limit is given to the motion of the bolt when the stop (*b*, Fig. 6) reaches the shoulder (*s*, Fig. 11) on the receiver.

The mechanism will then be as shown in Fig. 1.

A cartridge can now be loaded directly into the chamber, or, if the magazine is on, its upper cartridge will rise into the passage (*e*, Figs. 13 and 16) until the upper part of the cartridge head is in front of the lower part of the bolthead.

Moving the bolt directly forward the bullet will enter the chamber. During this motion the nose (*s*, Fig. 1) of the sear lies in the cut (*n*, Fig. 1) in the underside of the bolt, and when the front face (*a*, Fig. 4; *f*, Fig. 1) of the cocking piece meets it stops its motion and that of the firing pin, while that of the bolt body and the rear bearing (*w*, Fig. 2) of the mainspring continue, thus compressing the spring.

When the cams (*f*, Figs. 5 and 11) meet a motion of rotation is also given the bolt body, the cocking piece, and the firing pin; the shoulder (*a*, Fig. 5) revolves back the wedge under the left extractor, which then can grasp the cartridge head, and the face of the cocking piece revolves along the nose of the sear until the shoulder (*c*, Fig. 4) bears against it. Finally, the cartridge will be fully seated, the groove in the head engaging against the cartridge stop (*k*, Fig. 2) and the locking rib (*b*, Figs. 1 and 5) resting on the right wall (*d*, Fig. 13) of the receiver in front of the locking shoulder (*d*, Fig. 10). The mechanism will then be in the position shown in Fig. 2.

In case of a missfire the piece can be recocked by grasping the rear of the cocking piece with the fingers and drawing it directly back.

If the trigger is pulled before the arm is fully locked the projections (*b*, Fig. 7) on the firing pin will strike against the rear face of the bolt-head shank instead of entering the recess (*a*, Fig. 6), and the striker will not reach the primer.

No. 5.—DURST, No. 2.

This arm was submitted to the board by Mr. M. H. Durst, of Wheatland, Cal. Its magazine, cylindrical in shape and having a capacity of ten cartridges, lies directly below the receiver. It can be loaded with single cartridges, or they can be stripped from a clip.

The gun has a cut-off.

The stock is in two pieces, as in the Durst, No. 1.

The barrel and its ammunition is the same as in the Durst, No. 1, as is also the mechanism of the bolt and of the magazine.

The gun in fact is merely a duplicate of the Durst, No. 1.

No. 6.—DURST, No. 3.

This arm was submitted to the board by Mr. M. H. Durst, of Wheatland, Cal. Its magazine, cylindrical in shape and having a capacity of ten cartridges, lies directly below the receiver. It can be loaded with single cartridges, or they can be stripped from a clip.

The gun has a cut-off.

The stock is in two pieces, as in the other Durst guns.

The barrel is of the standard United States caliber, 0″.30, but is chambered for a special form of cartridge shell, almost a duplicate of that for the Lee-Speed, of England, except that it has a cannelured instead of flanged head.

The mechanism of the bolt and of the magazine is the same as that of the other Durst guns.

No. 7.—DURST, No. 4.

This arm was submitted to the board by Mr. M. H. Durst, of Wheatland, Cal. Its magazine, cylindrical in shape and having a capacity of ten cartridges, lies directly below the receiver. It can be loaded with single cartridges, or they can be stripped from a clip.

The gun has a cut-off.

The stock is in two pieces, as in the other Durst guns.

The barrel is of the standard United States caliber, 0″.30, but is chambered for a special form of cartridge shell, almost a duplicate of that for the Lee-Speed, of England, except that it has a cannelured instead of flanged head.

The mechanism of the bolt and of the magazine is the same as that of the other Durst guns.

No. 8.—BLAKE, No. 1.

(Plate V.)

This arm was submitted to the board by Mr. John H. Blake, of New York City.

The magazine, lying below the receiver, contains a revolving cylin-

drical packet holding seven cartridges. This packet is essential to the operation of the arm as a magazine gun. There is a cut-off.

In the plate, Fig. 1 shows the action open; Fig. 2, action closed in firing position.

Fig. 3 is a plan view of bolt in firing position; Fig. 4, a cross section on AA. Fig. 3, showing connection of extractor stud with bolt.

Figs. 5 and 6, cross sections on AA, Fig. 1, the former with the cartridge packet adjusted for magazine fire, the latter with the magazine in reserve.

Fig. 7 is a rear view of the cartridge packet, showing shoulders for the engagement of the cylinder hand and the holes for the cylinder bolt stop.

Fig. 8, left face of stock, showing cut-off lever.

DESCRIPTION.

The receiver has on its left-hand side a broad and deep groove (*a*, Figs. 1, 5, and 6) for the passage of the left locking lug (*a*, Figs. 2 and 3) of the bolt, and on the right a shoulder (*c*, Figs. 5 and 6) for the extractor (*b*, Fig. 3) and right locking lug (*c*, Figs. 2 and 3) of the bolt.

The entire bottom is cut away (*b*, Figs. 5 and 6) to permit the upward and forward movement of cartridges from the magazine. The forward breech casing contains the grooves for the locking lugs of the bolt, and on the right hand a cut for the hook of the extractor.

At the rear the breech casing for a short distance is closed at the top (*f*, Fig. 1), completely encircling the bolt; back of that a channel is left for the passage of the handle, while at the right a shoulder is formed, in front of which the base of the handle locks in the firing position.

The bolt consists of the body, the cocking piece and sleeve, the firing pin and spring, and the extractor.

The well of the body, except where closed for the striker (*e*, Figs. 1 and 2), is bored of one diameter. Near the front of the body are the two locking lugs (*a* and *c*, Fig. 3), the right-hand one having a shoulder against which the extractor rests as the bolt is moved back and forth; on top and on the right of the body is an opening (*d*, Figs. 1, 3, and 4), through which a lug (*d*, Fig. 3), on the under side of the extractor, passing through a corresponding cut in the sleeve (*e*, Fig. 4), bears against a flattened portion of the shank of the firing pin. On the left of the body is a stud (*e*, Fig. 3), which, as the bolt is pushed forward, impinges against the operating arm (*m*, Fig. 1) of the magazine, moving it forward and thereby lowering the cylinder hand (*n*, Figs. 1 and 2) from the position in Fig. 1 to that in Fig. 2, ready, as the hand is later raised, to rotate the cartridge packet. On the rear end of the bolt is the usual cam (*f*, Fig. 3) for forcing back the cocking piece as the handle is turned up to the left. The cocking piece (*b*, *d*, Fig. 2; *m*, Fig. 3) screws on to the end of the firing pin; it contains the notch for the nose of the sear (*p*, Fig. 2), and on its upper surface the nose (*m*, Fig. 3) which acts on the cam (*f*, Fig. 3) as above mentioned.

The sleeve has a tang (*h*, Fig. 1) which enters a fork (*k*, Fig. 1) in the forward end of the cocking piece; through a cut (*l*, Fig. 1) the stud (*d*, Fig. 4) on the under side of the extractor bears against the firing pin.

The firing pin and striker are in one piece; the shoulder of the striker and the front face of the sleeve form the two bearings for the mainspring.

The extractor consists of the hook and body. The hook (*b*, *c*, Fig. 3) rests between shoulders of the body, to which it is secured by a stud.

The body is attached to the bolt by the lug (*d*, Figs. 3 and 4), which passes through cuts made for that purpose in the bolt body and sleeve.

The ejector (*p*, Figs. 1 and 8) is pivoted on the left part of the breech casing. A spring bears against its lower surface.

The magazine casing consists of a cylindrical box (*p*, *q*, Fig. 2; *d*, *e*, *f*, Figs. 5 and 6) placed below the receiver. Its bottom is hinged at the left side (*d*, Figs. 5 and 6), and when closed is secured by the catch (*e*, *f*, Figs. 5 and 6).

The cartridge packet (Fig. 7; *r*, *s*, Fig. 2) has at the front and rear ends (*m*, Fig. 7) trunnions, which rest in beds in the front and rear faces of the casing (*t*, Fig. 2).

The rear of the packet has shoulders (*b*, Fig. 7), where the hand (*u*, Fig. 2) engages, and holes (*c*, Fig. 7) in which the point of the cylinder stop (*h*, Fig. 2) enters to limit the rotation of the packet. The cartridges are placed on the beds (*r*, *s*, Fig. 2).

The operating arm (*a*, Fig. 8) of the cut-off is on the left of the stock, opposite the bolt handle; from it a stud engages on the lower part of the arm (*m*, Figs. 1 and 2), and when single-loading fire only is desired can so depress the arm that the lug and stud (*a* and *r*, Fig. 3) of the bolt will pass over without operating it.

If it is desired to load the magazine and hold it in reserve the bolt must first be closed; then, opening the casing, placing the packet with its trunnions in their beds, and closing the casing smartly, the packet will be forced to take the position shown in Fig. 6. Then, with magazine cut-off, single-loader fire can be delivered. It is essential that the cut-off be operated only when the bolt is entirely or partly closed.

Presuming the piece to have been fired, turning up the handle throws, in consequence of the cam (*f*, Fig. 3) and nose (*m*, Fig. 3), the cocking piece, and therefore the firing pin, to the rear; but as the stud (*d*, Figs. 3 and 4) on the extractor passing through the body and sleeve prevents the latter from traversing the well of the former, the rear bearing of the mainspring does not change its position, and as the striker is drawn back the space for the mainspring is lessened, thus compressing it. When the upward motion of the handle is a little over half completed, its base, by the inclined surface of the shoulder of the breech casing, is moved slowly back, starting the bolt to the rear and loosening the empty shell. After rotation is completed, as soon as the bolt is drawn back the notch (*c*, Fig. 1) passes the nose of the sear. When almost fully back, the locking lug (*a*, Fig. 3) abuts against the arm (*m*, Fig. 2), revolving it back. Withdrawing the cylinder stop (*h*, Fig. 2) from its engagement in the rear (*c*, Fig. 7) of the packet and lifting the cylinder hand (*n*, Fig. 2) causes, by the latter's bearing against a shoulder (*b*, Fig. 7) of the packet, a one-seventh revolution of the cylinder, bringing a second cartridge (*m*, Fig. 5) into the bottom of the receiver in front of the bolt.

Reversing the movement of the bolt, the stud (*e*, Fig. 3) meets the arm (*m*, Fig. 1), moves it forward and lowers the hand (*n*, Fig. 1) until it engages below a second of the shoulders (*b*, Fig. 7) on the cylinder packet. As this motion is completed the cocking piece is stopped by the nose of the sear, and as the handle is turned down to the right the firing pin and striker are held, while the sleeve and body of the bolt moving slightly forward, the mainspring space is lessened, this time from the rear, completing its compression.

At the same time the cartridge is pushed fully into the chamber and the recoil or locking lugs (*a* and *c*, Figs. 2 and 3) seated in front of the shoulders (*b*, Fig. 1) in the casing.

The piece can not be fired unless fully locked; for, as the trigger is pulled, the nose (*p*, Fig. 2) of the sear can not leave the notch until the arm (*f*, Fig. 2), of which it forms a part, rises into a narrow cut provided on the lower side of the bolt for that purpose.

A friction spring (*w*, Fig. 2) is introduced in the bottom of the cover of the magazine casing to control the revolution of the packet and prevent, in connection with the stop bolt (*h*, Fig. 2), the cylinder throwing past when the mechanism is rapidly manipulated; a shoulder at the rear of the lower right face of the receiver also prevents too great a movement of the packet.

No. 9.—RUSSELL-LIVERMORE, No. 1.

(Plate VI.)

This gun was submitted to the Board by Maj. W. R. Livermore, Corps of Engineers, U. S. Army, and Capt. A. H. Russell, Ordnance Department, U. S. Army.

The barrel and breech bolt are the same as on the Lee-Speed, Mark I, of England, and the arm is adapted to that cartridge. The receiver in all essential features is also the same.

On this gun the magazine holding five cartridges of Maj. Livermore and Capt. Russell has been substituted for that of the Lee pattern.

The gun has a cut-off.

In the plate Fig. 1 is a longitudinal section of the magazine and receiver.

Fig. 2, a side view of the same.

Fig. 3, a side view of the loading packet.

Fig. 4, a section of magazine box and carrier lever on AA, Fig. 1.

DESCRIPTION.

The magazine box is in two pieces, the right face being attached to the receiver by a small screw (*a*, Fig. 2) just below the chamber and to the guard by another screw (*c*, Fig. 2). The left face, made in one with the trigger guard, is secured by a screw to the left wall of the receiver. The collar (*b*, Fig. 2), and the screw (*n*, Fig. 2), connect the two faces of the box.

Fastened to the right face by a screw (*f*, Fig. 2) is a flat spring (*d*, Fig. 2), whose overturned lip (*r*. Fig. 2) retains the cartridges after they have been placed in the magazine.

The front of the box (*v*, Fig. 2) and the inside of the stock have been cut away to permit action of the arm (*e*, Figs. 1 and 2) of the carrier lever. A portion (*c*, Fig. 1) of the bottom of the box is open to permit passage through it of the loading packet (Fig. 3), and a part of the sides of the box are cut away (*h*, Fig. 2) to allow the fingers to grasp the packet, which is roughened (*b*, Fig. 3) to afford a surer hold when drawing it from the box.

Secured by rivets (*p*, Figs. 1 and 2) to the sight base is a sleeve (*p*, *p*, *k*, Figs. 1 and 2), embracing the sides and bottom of the barrel and affording at its under side the support for the carrier lever. This lever (*n*, *m*, *e*, Figs. 1 and 2), is composed of the long arm (*e*, Figs. 1 and 2), pivoted by a screw (*t*, Figs. 1 and 2) to the sleeve, of the follower portion (*n*, Figs. 1 and 2), and of the connecting arm (*m*, Figs. 1 and 2); these parts are all in one piece. Acting on the heel of the lever is the

magazine spring (*w*, Figs. 1 and 2). The stud (*s*, Figs. 1 and 2) limits in both directions the motion of the lever. The magazine mechanism operates as follows: The packet (Fig. 3) having been loaded, the points (*a a*, Fig. 3) are bent over the cartridges to secure them in the packet.

Introducing the packet through the receiver into the rear part of the magazine box it lowers the lever, compressing the magazine spring (*w*, Figs. 1 and 2). The packet is then grasped from below by the thumb and finger and pulled through the box, entirely withdrawing it from the magazine, in which, through the intervention of the follower portion (*n*, Figs. 1 and 2) of the lever, the cartridges are retained. The flat spring (*r*, Fig. 2) on right side of the magazine projects over the upper cartridge and prevents its rising too far into the receiver. Closing the bolt, this first cartridge is pushed into the chamber, the remainder being lifted by the lever until the upper one rests against the under side of the bolt, in front of which it in turn rises as the bolt is entirely withdrawn.

No. 10.—RUSSELL-LIVERMORE, No. 2.

(Plate VI.)

This arm was submitted to the board by Maj. W. R. Livermore, Corps of Engineers, U. S. Army, and Capt. A. H. Russell, Ordnance Department, U. S. Army.

The barrel and breech bolt are the same as the Lee-Speed, Mark I, of England, and the arm is adapted to that cartridge, the English magazine being removed and the receiver modified as far as necessary to conform to the Russell-Livermore magazine.

The magazine can be cut off.

In the plate, Fig. 1 is a side view and part vertical section of the magazine.

Fig. 2, a plan view and horizontal section.

Fig. 3, a cross section of the magazine on AA, Fig. 1.

Fig. 4, a cross section on BB, Fig. 1.

Fig. 5, side view of magazine spring and thumb piece of carrier lever.

DESCRIPTION.

The receiver is the same as in the Lee-Speed, Mark I.

The magazine (Fig. 3; *a*, Figs. 1 and 2) is attached to the under side of the receiver by mortise and tenon and by a rivet. On the left side it is even with the left of the receiver; on the right (*a*, Fig. 2) it projects out beyond and below it.

The upper and lower walls of the magazine (*a a*, Fig. 3) are connected together at the front by a screw (*b*, Fig. 1). The back of the box (*d*, Fig. 1) joins the two walls at the rear.

This rear wall (*d*, Figs. 1 and 2) is curved, and with the front face so directs the movement of the cartridges that the head of one is always in advance of the head of the succeeding. On the left the magazine merges into the left wall (*d*, Fig. 3) of the receiver; on the right side it projects considerably (Fig. 1) beyond the stock, on the floor (*c*, Fig. 3) to a greater distance than the top, thus leaving an opening (*e*, Fig. 3) through which cartridges can be introduced when the lever (*e*, Fig. 1) and the follower (*n*, Figs. 1 and 3) are retracted. The right-hand guide rail (*b*, Fig. 3) of the receiver forms a portion of the upper wall of the magazine.

Secured to the sight base by a screw (*p*, Fig. 1) is a sleeve (*f*, Figs. 1 and 4) which embraces the under side of the barrel; to this sleeve is pivoted the carrier lever (*e*, Figs. 1, 4, and 5) by a screw (*a*, Figs. 4 and 5); a set screw (*d*, Fig. 4) prevents motion of this pivot; the magazine spring (*c*, Fig. 5) acting on the heel (*b*, Fig. 5) of the lever tends to carry it and the follower forward into the magazine. The lever terminates in a thumb piece (*h*, Figs. 2 and 5) by which, when pressure is given, the lever and follower are retracted to the position shown in Figs. 1 and 3, leaving free the opening (*e*, Fig. 3) of the magazine.

The follower (*n*, Figs. 1, 2, and 3) is made in one piece with the lever; it is so shaped as to bear against the body of the cartridge and also upon the bullet.

The cut-off is pivoted back of the left wall of the receiver, beyond which its thumb piece (*t*, Fig. 2) lies.

The blade (*r*, Fig. 2) is also outside the receiver when arranged for magazine fire.

To cut off the magazine, the thumb piece is moved forward (*w*, Fig. 2), throwing the blade (*r*, Fig. 2) over the first cartridge in the magazine. It can be operated with the magazine either empty or full and with the bolt either closed or open.

No. 11.—RUSSELL-LIVERMORE, No. 3.

This arm was submitted by Maj. W. R. Livermore, Corps of Engineers U. S. Army, and Capt. A. H. Russell, Ordnance Department U. S. Army.

The breech bolt is the same as the Lee-Speed, Mark I, of England, but the barrel is of .30 caliber and chambered for the Frankford Arsenal experimental cartridge.

The receiver is the same as on the Lee-Speed.

The space usually occupied by the magazine box is in this arm inclosed on the left side by the stock, at the rear by a plate forming the end of the butt-stock, and on the front by another plate facing the end of the fore-stock, and having a vertical channel for the movement of the carrier lever. What would be the bottom and the right face of a magazine box are removed, leaving a rectangular opening into which the cartridge packet is placed after the forks of the lever have been depressed.

This packet then forms the actual magazine box and is held in place merely by engaging at the top under the rails of the receiver and by the pressure of the carrier lever underneath.

The carrier, its forks, and the magazine spring are similar to and work upon the same principle as the Russell-Livermore, No. 1.

It was proposed by the inventors to provide a cut-off, but none had been arranged on the arm when submitted to the board.

No. 12.—WHITE.

(Plate VII.)

This arm was submitted to the board by the White Magazine Rifle Company.

The permanent portion of the magazine mechanism is contained in a

box located directly below the receiver; the remainder, in the form of a light packet, is introduced into the magazine with the cartridges, which it holds. This packet is an essential portion of the mechanism.

The gun has a cut-off.

In the plate Figs. 1 and 2 are longitudinal sections of the assembled breech and magazine mechanism; the former with action open and magazine full, the latter with action closed, magazine partly emptied.

Figs. 3 and 4; right and left side, respectively, of receiver.

Figs. 5, 6, and 7; top, right hand, and front views, respectively, of bolt body.

Figs. 8, 9, and 10; under side, right hand, and front views, respectively, of bolt slide.

Fig. 11; rear, top, and under side of locking block.
Fig. 12; interior bolt cover.
Fig. 13; right side and top views of extractor.
Fig. 14; right side and top views of extractor locking bar.
Fig. 15; cut-off.
Fig. 16; magazine cartridge packet.

DESCRIPTION.

The sides of the receiver are vertical. In the left wall is a channel (*a b*, Figs. 1 and 4) for the movement of the left side of the locking block when the bolt is drawn back; the rear of this channel (*a*, Fig. 4) acts with the locking block as a bolt stop; near the front is a rib (*c e*, Figs. 1 and 4; *e*, Fig. 3) whose front face (*c*, Figs. 1 and 4) sustains the left end of the block at discharge; near the rear end the rib (*a d*, Fig. 4; *a*, Figs. 1 and 3) engages in the groove (*a d*, Fig. 11) in the block. In the right wall is a mortise (*b c*, Fig. 3) for the right side of the block in the locked position. A portion of the wall (*d h*, Fig. 3) is cut away to permit removal of the block for the purpose of dismounting the bolt. Back of the receiver both walls (*m*, Figs. 3 and 4) rise to the level of the top of the bolt, which they partly embrace. At the lower edge of the walls are cuts (*h*, Figs. 1 and 4) for the follower guide ribs of the magazine box; for the cartridge packet ejector (*n*, Fig. 4); for the cut-off slide (*p*, Fig. 4); for the front wall (*p*, Fig. 2; *q*, Figs. 3 and 4) of the magazine, and recesses (*r r*, Figs. 2, 3, and 4) to engage over corresponding shoulders in the stock.

The bottom of the receiver is entirely cut away to permit the introduction of the cartridge packet into the magazine. A ramp (*r*, Fig. 1) at the front guides the bullets as the cartridges are pushed by the bolt into the chamber. At the extreme front the breech casing (*d*, Figs. 1 and 2) covers the top of the receiver, having a cut (*a*, Fig. 2) for the extractor locking rib.

The bolt is composed of the body, the cover, the slide, and the locking block. The body is closed at the bottom except for a groove near the rear (*a*, Fig. 5) to permit passage of the cocking piece (*n*, Fig. 1); further forward the well is enlarged (*c b*, Fig. 5) to afford space for the mainspring, and still further to the front (*b d*, Fig. 5) for the head (*b c*, Fig. 2) of the firing pin. At the extreme front the top of the bolt is closed, leaving a conical space for the striker portion of the firing pin and a cut (*e*, Figs. 2, 5, and 7) for the extractor. On the face of the bolt are channels (*n*, Figs. 5, 6, and 7) to permit escape of gas in case of a blow back through the primer pocket or of a ruptured cartridge shell.

The sides of the body near the head (*f h*, Figs. 5 and 6) are cut away, affording space for the reception and movement of the locking

block, the studs (*m*, Figs. 5 and 6) engaging in the groove (*m m*, Fig. 11) on the under side of the block. The cover (Fig. 12; *n n*, Fig. 2) completes the upper part of the bolt body from the rear shoulders (*h*, Fig. 5) for the locking block to the rear bearing (*c*, Fig. 5) of the main-spring. The slide embraces in its rear half (*a b*, Figs. 8 and 9; *g k*, Fig. 1) the rear half (*a b*, Figs. 5 and 6) of the body and its cover (Fig. 12) with an arm (*b f*, Figs. 8 and 9; *f m*, Fig. 1) projecting over the remainder of the body to the shoulders (*c*, Fig. 6) on the head.

A channel (*r*, Figs. 8, 9, and 10) in the bottom of the rear half of the slide permits passage of the cocking piece; vertical cuts (*p*, Figs. 1 and 8) permit the insertion and operation of the safety lock and its spring. To the extreme rear of the slide the handle (*h*, Figs. 8, 9, and 10) is attached. On the upper part of the slide is a cut (*s*, Figs. 1 and 8) for the securing stud (*s*, Fig. 14) of the extractor locking bar. On the under side of the arm is a rib (*c*, Figs. 8, 9, and 10) which, acting as a guide, engages in a channel left between the cover and the left side of the body of the bolt, and a cam way (*d m*, Fig. 8) along which the stud (*s*, Fig. 11) travels as the slide is moved back and forth to operate the bolt. Into the recess (*e*, Figs. 8 and 10) the front of the extractor locking bar (*e*, Fig. 14) enters as the action is closed.

The locking block (Fig. 11; *t*, Fig. 1) has a motion across the bolt body in a channel (*h f*, Figs. 5 and 6); it enters a recess (*c b*, Figs. 3 and 4) in the right wall of the receiver when the bolt is locked, and moves with the bolt along a channel (*a b*, Fig. 4) in the left wall as the bolt is withdrawn or returned. At the rear, on the under side, are recesses (*c* and *e*, Fig. 11) into which the stud (*m*, Fig. 1) on the upper side of the semicylindrical head of the firing pin enters in the operation of the mechanism, as hereafter explained.

The firing pin (*b c f*, Fig. 2) is connected by a ball and socket joint (*f*, Fig. 2) with the flat cocking piece (*f h*, Fig. 2). On the bottom of the cocking piece is the full-cock notch (*n*, Fig. 1) and on the top notches (*k*, Fig. 2) in which the blade of the safety lock can be engaged.

The extractor lies in a cut (*e*, Fig. 5) in the top of the head of the bolt, its heel engaging as shown (*e*, Fig. 2).

The extractor locking bar (Fig. 14; *l*, Fig. 1) moves on the upper part of the slide, its hook (*e*, Fig. 14) bearing, when the bolt is locked, under the shoulder (*a*, Fig. 2) in the breech casing and upon the front (*a*, Fig. 13) of the extractor; this bar serves also as a spring to retain the hold of the extractor upon the cartridge shell after it is withdrawn from the chamber.

The ejector (*w*, Figs. 1, 2, and 3) is pivoted on the same pin (*f*, Fig. 3) which guides the motion of the cut-off. By the sear and ejector plate (*p p*, Fig. 3), which is pivoted to the sear and bears also against the heel of the ejector, the sear spring (*y*, Fig. 1) is also made to serve as an ejector spring.

The magazine is composed of the metal packet (Fig. 16) and other parts contained in a metal box lying below the receiver and in front of the trigger guard. This box consists of two side plates each with guide ribs prolonged upwards and ending (*h*, Fig. 1) in recesses made to receive them in the receiver; within these ribs are curved grooves (*l*, Fig. 2) for the ends of the follower spring pin (*t*, Fig. 2) and for a corresponding pin acting as trunnions on the follower itself (*m m*, Fig. 2). At the front the magazine itself is closed by the plate (*p p*, Fig. 2) though the box is prolonged and has two holes (*g*, Fig. 2) for the ends of the magazine spring. At the bottom, half of the box is closed by the plate (*x*, Fig. 2); the remainder is open (*z*, Fig. 2) to permit ejection of the empty cartridge packet.

The rear wall is grooved, affording a channel for the securing shoulder (*n*, Fig. 16) on the packet.

The follower (*m m*, Fig. 2) has ribs on either edge of the lower side to guide the magazine spring; its trunnions move in the grooves (*l*, Fig. 2) of the box. The follower spring (*q q*, Fig. 2) bears at the front only of the follower, when the magazine is full (Fig. 1); at both ends, when it is partly empty (Fig. 2). The cartridge packet (Fig. 16; *y*, Fig 2) holds five cartridges, which are retained therein by the overturned lips (*a a*, Fig. 16) at top and bottom and by the spring bearing of the sides (*b*, Fig. 16). The packet is as essential as the follower or magazine spring to the proper operation of the system.

Presuming the piece to have been fired, the subsequent operation of the mechanism is as follows:

Drawing back the handle moves at first nothing but the bolt slide, the cam way (*d m*, Fig. 8) sliding meanwhile over the stud (*s*, Fig. 11; *m*, Fig. 1) on the locking block. As the curved side (*n*, Fig. 8) of this cam way bears against the stud it starts the locking block and finally moves it out of the recess (*b c*, Figs. 1, 3, and 4) in the right-hand wall of the receiver. During this motion the stud (*t*, Fig. 1) on the upper side of the firing pin head is cammed back by the sloping side (*c*, Fig. 11) of the recess on the under side of the block, thus withdrawing the point of the pin from the face of the cartridge head; at the completion of the side movement of the block this stud falls into the second recess (*e*, Fig. 11), where it is retained by the pressure of the mainspring, and limits further lateral travel of the block.

The block also, on account of its sloping locking shoulders (*b b*, Fig. 11) is moved slightly to the rear starting the bolt and the empty cartridge shell. The shoulder (*v*, Fig. 8) on the slide then bearing against the stud, further pull on the handle brings the block and with it the bolt and extractor to the rear, withdrawing the empty shell. As the motion is nearly completed the ejector, which has traversed the groove (*p p*, Fig. 7), rises as the bolthead passes over it, and meeting the cartridge head throws the shell out of the receiver. Motion is finally stopped by the locking block impinging against the shoulder (*a*, Fig. 4) on the receiver.

The gun may then be loaded as a single loader or a packet with cartridges put into the magazine and pushed down until the shoulder (*n*, Fig. 16) engages over the point of the catch (*n*, Figs. 3 and 15; *m*, Fig. 2) at the end of the cut-off; the upward pressure of the magazine spring will retain it in this position.

The mechanism will then be as shown in Fig. 1.

Pushing forward the bolt it will take the upper cartridge, moving it along the under side of the overturned lips (*a*, Fig. 16) of the packet. The locking block, which, under the influence of the edge (*w m*, Fig. 8) of the cam way tends to move to the right, is at first prevented from doing so by the engagement of the stud on the firing pin in the recess (*e*, Fig. 11) on the block; later the nose of the sear (*s*, Fig. 2) meets the cock notch (*n*, Fig. 1), stopping the movement of the firing pin; but not until the block can enter the mortise (*b c*, Fig. 3) on the right side, and move in front of the shoulder (*c*, Figs. 1 and 4) on the left side of the receiver, does the lateral travel of the block commence.

Subsequent motion of the bolt body is slow, while that of the slide continues rapid.

The mainspring is compressed by the direct push forward of the bolt handle after the sear has engaged upon the face of the cocking notch.

In Figs. 1, 2, and 3 the mechanism is arranged for magazine fire.

To cut off the magazine press down on the thumb piece (*m*, Figs. 3 and 15); this lowers the whole cut-off, carrying with it the prong (*n*, Figs. 3 and 15) and consequently the entire packet of cartridges, depressing them below the reach of the bolt.

The full packet can be removed by bearing down upon the upper end (*n*, Fig. 4) of the lever (*n w*, Fig. 4) until it releases the point (*v*, Fig. 4; *n*, Fig. 15) from the shoulder on the packet. The pressure of the magazine spring will then throw the packet upward.

After all the cartridges are carried into the chamber, the packet will fall to the ground through the cut (*z*, Fig. 2) in the bottom of the magazine box.

If the trigger is pulled before the mechanism is locked the stud on the firing pin will not enter the recess (*c*, Fig. 11) in the block and the striker will not reach the primer.

In case of a missfire the piece can be recocked by grasping the handle (*h*, Fig. 2) of the cocking piece and drawing it back until the notch again engages over the point of the sear.

No. 13.—HAMPDEN.

(Plate VIII.)

This arm was submitted by Mr. Thomas B. Wilson, of East Boston, Mass.

The capacity of the magazine is 5 cartridges. The gun has a cut-off.

In the plates Figs. 1 and 2 are longitudinal sections, the former showing the action open, the latter the action closed, ready for firing.

Fig. 3 is a section on AA, Fig. 1, showing the receiver and magazine and magazine cut-off.

Fig. 4 is a section on BB, Fig. 1, showing the cam for the locking lug and recess for extractor hook.

Fig. 5 is a section on CC, Fig. 2, showing the extractor, the guide ways of the breech casing, and the cocking piece.

Fig. 6 is a section of DD, Fig. 2, showing the extractor and locking lug in firing position.

Fig. 7 is a plan view of the bolt, the mechanism being as given in Fig. 1.

Fig. 8, rear view of bolt, showing cocking cam.

Fig. 9, side view of extractor.

Fig. 10, the loading packet.

DESCRIPTION.

This arm possesses the peculiarity that, with the exception of the cut-off, there are no springs, carrier levers, or followers about the magazine. The magazine is a simple box in which the cartridges are placed and are fed down to the receiver by the action of gravity alone.

The receiver is cut away at the right side, leaving a straight shoulder (*a*, Figs. 1 and 3), upon which the long guide and locking rib (*b*, Fig. 1) of the bolt rests when ready for firing. Next this shoulder the bottom of the receiver (*c*, Fig. 3) is slightly curved to conform to the shape of the bolt and the other half of the bottom is cut (*d*, Fig. 3) at an abrupt shoulder, forming a pocket for the first cartridge from the magazine. Above this pocket a straight rail (*f*, Figs. 1 and 3) closes the left side of the receiver proper. Between this rail and the bottom of the pocket is the passage (Fig. 3) for the movement of cartridges from the magazine. At the bottom of the receiver is a short longitudinal cut (*n*, Fig. 3) for the end of the cut-off.

Back of the receiver the right side (*e*, Fig. 5) of the breech casing rises to the level of the left rail (*f*, Fig. 5) of the receiver, forming with it a channel for the passage of the extractor body (*d*, Figs. 1, 2, and 5) and the guide rib (*b*, Fig. 1) on the bolt. Below this in the casing is a socket (*c*, Figs. 1 and 2) for the ejector, and in the tang a channel (*e*, Figs. 1 and 2) for the passage of the nose of the cocking piece (*h*, Figs. 1 and 2). Forward in the casing is a cut for the hook (*a*, Figs. 2, 4, and 6) of the extractor, a cam way (*f*, Figs. 4 and 6) to direct the movement of the locking lug (*b*, Figs. 6 and 7), and a recess (*k*, Figs. 1, 2, and 4) which it enters when locked.

Gas ports (*m*, Fig. 1) are provided in the breech casing.

The bolt (Fig. 7) consists of the body, with its guide rib (*b*, Fig. 1), operating handle (*f*, Fig. 7), and locking lug (*b*, Fig 7) of the firing pin (*f*, Fig. 2) and cocking piece (*h*, Fig. 2), which are in one, and of the firing-pin sleeve (*n*, Figs. 1 and 7).

The well of the body is bored of one dimension, except as closed at the front, for the passage of the striker (*b*, Fig. 2). At the rear of the body is the cam (*a*, Figs. 7 and 8) for throwing back the cocking piece, and a notch (*c*, Figs. 7 and 8) for retaining it as the bolt is drawn back.

This cam is made in a reënforced portion of the bolt (*p*, Figs. 1 and 7), whose forward shoulder is undercut for the retaining hook (*b*, Fig. 9) of the extractor.

The firing pin consists of the straight body terminated at the rear in the cocking piece (*h*, Figs. 1, 2, and 7). This cocking piece has the full and half cock notches on its lower side (*h*, Fig. 1) and on its upper a guide rib (*b*, Figs. 1 and 2), which enters a slot (*e*, Fig. 7) in the sleeve. At the forward end (*n*, Fig. 2) the pin enters a socket joint in the striker (*b*, Fig. 2). The sleeve (*n*, Figs. 1 and 7) moves on the firing pin and is forked at the rear (*e*, Fig. 7) to slide over the cocking piece.

It is retained in position by the hooks (*s*, Figs. 1 and 2), which engage upon the rear hook (*c*, Fig. 9) of the extractor. The forward end (*m*, Fig. 2) of the sleeve and the rear end (*n*, Fig. 2) of the striker give the two bearing surfaces for the mainspring.

The extractor (Fig. 9, *d*, Figs. 1 and 2), by its hooks (*b* and *c*, Fig. 9), engaging over the body of the bolt and the sleeve, assembles the parts of the bolt; it is composed of the body (*d*, Fig. 1) and of the extractor proper (*a*, Figs. 2 and 9), which is secured in a socket in the forward end of the body by its lug (*t*, Fig. 1) and a retaining pin.

The ejector (*c*, Figs. 1 and 2) is a curved spring with a stud (*w*, Fig. 1) projecting through into the bottom of the receiver. The stud rises as a slot in the head of the bolt passes over it.

The sear is of rather novel design, but its operation, with that of the trigger, is sufficiently indicated by the drawing (Figs. 1 and 2).

The magazine is a metal box, which rises to the left and above the left wall (*f*, Fig. 3) of the receiver. The right side (*i*, Figs. 1, 2, and 3) of the box is the extension upwards of this receiver wall; the left side of the box curves inward to the right at the bottom and joins the bottom of the receiver. The right side is hinged (*y*, Fig. 1) to the front and rear ends of the box, and, opening upwards and to the right, acts as a gate to the magazine, through which, when opened, the cartridges can be introduced.

It is operated by a cut (*q*, Figs. 1 and 3) for the thumb and a shoulder (*x*, Figs. 1 and 3) for the forefinger of the right hand.

The cut-off (*b c n*, Fig. 3) is placed on the outside of the left wall of the magazine box, its lower part bending round and issuing through

the cut (*n*, Fig. 3) in the bottom of the receiver. It is kept in the position set by the retaining friction screw (*e*, Fig. 3) and is raised or lowered by depressing or lifting the thumb piece (*h*, Fig. 3) at its upper end.

The cartridge packet, Fig. 10, is intended only to facilitate charging the magazine; it is not an essential portion of the mechanism. Placing the cartridges on the bottom (*a*, Fig. 1) of the charger and engaging the flap (*b*, Fig. 10) in the catch (*c*, Fig. 10), they are retained in place. Holding the charger over the opening of the magazine and releasing the catch with the thumb, the cartridges slide down into the magazine.

Presuming the piece to have been fired, as the bolt handle is turned up, the cocking piece, being engaged in the groove in the tang, is prevented from turning, and consequently by the cam on the rear end of the bolt is forced back, partly compressing the mainspring. When the upward motion of the handle is nearly completed, its base bearing against the right shoulder of the breech casing and the locking lug bearing in the cam (*f*, Fig. 6), the entire bolt is moved slowly to the rear, starting the empty shell. During this preliminary extraction the compression of the mainspring is continued, the nose of the cocking piece entering finally the notch (*c*, Figs. 7 and 8) at the end of the bolt. Now, drawing back the bolt, the full-cock notch immediately passes the nose of the sear, the extraction of the shell will be continued, and, when its head meets the ejector, will be thrown out of the receiver. Motion of the bolt to the rear is limited by the locking lug abutting against the forward part of the right shoulder (*e*, Fig. 5) of the breech casing.

As the bolt passes the mouth of the magazine the lower cartridge, which until then it has sustained, will fully enter the pocket (*d*, Fig. 3) in the receiver, its head just sufficiently (Fig. 3) above the floor of the receiver to be in front of the bolt.

Returning the bolt this cartridge is driven forward into the chamber and the mouth of the magazine closed to a second cartridge by the bolt itself. When the base of the handle reaches the rear part of the right shoulder of the breech casing its further direct motion is stopped. Just before that moment the sear again engages on the full-cock notch. Turning down the handle the locking lug enters its recess, and the bolt moving slightly forward the mainspring is still further compressed as the cartridge is fully seated.

The piece can be cocked as described, or, by turning up the handle, very slightly withdrawing the bolt and returning it to its firing position, or the cocking piece grasped through the ring at its end, can be drawn back directly.

There is no safety lock, but the cocking piece can be let down until the sear engages in the half-cock notch (*h*, Fig. 1), or the same engagement can be obtained by (after loading) partly turning up the bolt handle and then returning it to the firing position.

No. 14. BLAKE No. 2.

This gun was submitted by Mr. John H. Blake, of New York, at the close of the second period (before May 1) designated by the Secretary of War for the reception of magazine arms.

In system it is identical with the Blake No. 1, previously described and illustrated (see No. 8, on list of guns. Plate v).

PART III.—*Synopsis of the tests of arms by the board.*

Programme of the tests prescribed by the board for trial of guns submitted will be found in the proceedings for March 11, 1893.

In the application of these tests, that for safety was fired either by the inventor or, in his absence, by the recorder of the board.

For this test all guns were used as single loaders only, the cartridges being conveniently disposed upon a table near the operator.

The tests for rapidity with accuracy and rapidity at will were fired by the recorder of the board and by Mr. R. T. Hare, an employé of the Springfield Armory, the cartridges for the firing being conveniently arranged upon a table placed at the side of the operator.

In the remainder of the regular tests the firing was conducted from a fixed rest, the guns being operated by the members of the board and by Mr. Hare.

None of the guns passing these tests in a manner satisfactory to the board, neither the supplementary tests nor the additional tests enumerated in the programme of tests were applied to any arm.

No. 1.—Spencer-Lee.

SAFETY TEST.

This test and all subsequent tests down to the seventh of the regular tests were omitted.

VII.—EASE OF MANIPULATION.

Mechanism not operated with ease.

System complicated and obsolete and entirely unsuited for the military service.

No. 2.—Lee Model, 1893.

SAFETY TEST.

The gun was operated by Mr. J. P. Lee and fired from the shoulder, as a single-loader, 10 shots in thirty-two seconds.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 10 cartridges, it was endeavored to fire 10 shots as a single-loader and then the 10 from the magazine.

On the first trial after the 10 shots as a single-loader had been fired in twenty-nine seconds the magazine was turned on and 7 of its car-

tridges fired in twenty-six seconds; total for the 17 shots, fifty-five seconds; 17 hits.

The eighth cartridge from the magazine jammed as it was being pushed into chamber, entirely blocking the mechanism. During the magazine fire there had previously been three failures to properly feed from the magazine and one partial jam.

On second trial the 10 shots as a single-loader were fired in thirty-six seconds, the 10 from the magazine in nineteen seconds; total, fifty-five seconds; 20 hits.

During the single-loading fire there was one failure to eject, and one ejected shell fell back into receiver; both shells removed by operator's fingers.

(*b*) *As a single loader for two minutes.*—Thirty-eight shots were fired with 37 hits.

During this test it was observed that although the mechanism was such as to permit rapid working, yet the firing being conducted with magazine empty, there was no floor to receiver and it was therefore necessary when loading to insert cartridges more than half way into chamber before starting to close bolt.

If they were not pushed in far enough they would fall through receiver to the ground, or else if catching in receiver block the mechanism.

(*c*) *As magazine arm for two minutes.*—On first trial, after 6 shots had been fired in fifteen seconds, in endeavoring to overcome the jam of a cartridge entering the chamber, the operator, manipulating the bolt, inadvertently drew it back so far as to feed a second cartridge from magazine, causing a complete block.

On second trial 51 shots were fired with 49 hits and 9 cartridges left in magazine—two slight jams of cartridges when passing from magazine to chamber, overcome by operator making the additional motion of slightly withdrawing bolt.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The 10 shots as a single-loader were fired in twenty-five seconds, the magazine then turned on and its 10 cartridges fired in twelve seconds; total, thirty-seven seconds.

(*b*) *As single-loader for one minute.*—Twenty-one shots were fired and 1 cartridge inserted in chamber. One additional cartridge fumbled and dropped by operator.

Necessary to insert cartridges well into chamber as in corresponding portion of first regular test.

(*c*) *As magazine arm for one minute.*—Forty shots were fired.

III.—*Endurance.*

(*a*) *As magazine arm for 500 rounds.*—Cartridges in four instances not properly fed up from magazine, and in eleven other instances jammed when they were pushed forward into chamber. To fully close and lock bolt generally required a sharp, strong movement from operator, and a similar action to lift bolt handle after firing.

The test was conducted with the gun placed in a fixed rest, having a slide which permitted recoil, but not as freely as if fired from the shoulder. It was observed that if the operator removed his hand from the bolt handle before pulling the trigger the handle always rose, to a

greater or less extent, in a number of cases sufficiently to entirely unlock the bolt, leaving it free to move to the rear. If the hand was even lightly held on the handle this did not occur.

(*b*) *As single loader for 100 rounds.*—Bolt unlocked after each discharge, as before, whenever operator's hand was removed from handle.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Fairly well dusted; considerable force required to operate mechanism.

(*b*) *Magazine loaded when exposed.*—Well dusted; great force always required to operate mechanism, blows from a mallet being required both to open and close bolt in several instances.

V.—*Defective cartridges.*

Test omitted at request of inventor.

VI.—*Excessive charges.*

Test omitted at request of inventor.

VII.—*Ease of manipulation.*

When thoroughly cleaned mechanism easily and quickly operated. If not clean, much force required. Construction not simple, tendency of bolt to open a serious defect. System not suited to the military service.

No. 3.—Savage.

SAFETY TEST.

The gun was operated by the inventor, Mr. Arthur Savage, and fired from the shoulder, as a single-loader, ten shots in twenty-three seconds.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The full capacity of the magazine is nine cartridges. The gun has no cut-off, but by charging the magazine with only eight cartridges additional cartridges can be introduced into and fired successively from the magazine, holding meanwhile the eight cartridges in reserve.

Conducting the test in this manner 12 shots were fired in thirty-eight seconds, the 8 from the magazine in twenty seconds; total, fifty-eight seconds; 15 hits. There was one misfire.

(*b*) *As single-loader for two minutes.*—Thirty-three shots were fired, with 29 hits. There were 2 misfires, failed on second and third trials. Operator failed three times on first motion to entirely close lever.

(*c*) *As magazine arm for two minutes.*—The loading packets holding but six cartridges (though the magazine will contain nine), only the lesser number were introduced when charging the magazine.

From the nature of the magazine spring the force required to charge the magazine increases progressively with the number of cartridges, considerable exertion being required for each in excess of the number used.

Thirty shots were fired, 19 hits. Two missfires, in consequence of dummies having been inadvertently put into the loading packets instead of live cartridges. In consequence of the difficulty of stripping cartridges from one of the loading packets, the magazine in one instance was charged with single cartridges, somewhat delaying the firing.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—Trial conducted as for corresponding portion of first regular test.

The 12 shots as a single-loader in fifty-five seconds, the 8 from the magazine in eleven seconds; total, one minute and six seconds. In three instances the top cartridge from the magazine, in addition to the one inserted above it, fed up into the receiver and would have caused a jam when the bolt was pushed forward, except that it was noticed in time by the operator and pushed back into the magazine.

Operator failed once to fully close lever on first motion.

(*b*) *As single-loader for one minute.*—Twenty shots were fired. One missfire and one failure of operator to close lever to position on first motion.

(*c*) *As magazine arm for one minute.*—Magazine partly filled, each time from chargers holding six cartridges. Twenty-four shots were fired.

III.—*Endurance.*

(*a*) *As magazine arm for 500 rounds.*—Mechanism worked well, but required always the exertion of considerable force for its operation. Three missfires.

(*b*) *As single-loader for 100 rounds.*—Mechanism worked well, but required always the exertion of considerable force for its operation. Examining the cartridges from the magazine on conclusion of the firing, the case of the upper cartridge was observed to have been considerably scratched and lined by the repeated passage of the bolt and the cartridges successively introduced and the bullet to have been driven about 0.4 inch into the case.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Fairly well dusted. Increase of force required to charge the magazine and to operate the mechanism.

(*b*) *Magazine loaded when exposed.*—Well dusted. Mechanism worked fairly well.

V.—*Defective cartridges.*

No injury whatever from first defective. By second defective the extractor was slightly sprung and at first would not withdraw a cartridge. After removing a piece of the head of the cartridge case, which had lodged under the extractor, the extractor worked all right.

The automatic regulator or cut-off was also broken, preventing further use of the piece as a magazine arm, but not impairing its efficiency as a single-loader.

VI.—*Excessive charges.*

Test omitted.

VII.—*Ease of manipulation.*

Too great force required for the operation of the mechanism; system not well adapted for a military arm.

No. 4.—Durst No. 1.

This arm was submitted to the board by Mr. Durst, but before any tests had been applied was withdrawn by Mr. Durst pending the arrival of suitable ammunition for it from Europe and the proper adjustment of the gun to the expected cartridges.
It was not again submitted.

No. 5.—Durst No. 2.

SAFETY TEST.

The gun was operated by Mr. M. H. Durst, the inventor, and fired from the shoulder as a single loader, 10 shots in forty-five seconds. Bolt opened after each shot with much difficulty, requiring sharp blows from the operator's hand upon the handle.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 10 cartridges, 10 shots were first fired as a single-loader in fifty-nine seconds, the magazine turned on and its 10 cartridges fired in sixty-seven seconds; total for the 20 shots, two minutes and six seconds; 20 hits.

Bolt opened after every shot with great difficulty, much force being required to start the handle, blows from wooden mallet being necessary in three instances.

Gun withdrawn by inventor.

No. 6.—Durst No. 3.

SAFETY TEST.

The gun was operated by the inventor, Mr. M. H. Durst, and fired from the shoulder as a single-loader, 10 shots in twenty-nine seconds.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 10 cartridges, 10 shots were first fired as a single loader in twenty-eight seconds; the magazine then turned on, and its 10 shots fired in twenty-two seconds; total fifty seconds; 20 hits.

(*b*) *As single-loader for two minutes.*—Thirty-seven shots were fired and one cartridge inserted in the chamber; 36 hits. Two additional cartridges fumbled and dropped by operator. In three instances after the cartridge had been placed in the receiver the point of the bullet as the bolt was pushed forward impinged against the left face of the rear of the barrel, causing a slight jam; releasing pressure on the bolt the cartridge was freed and its insertion completed.

(*c*) *As magazine arm for two minutes.*—Forty shots were fired, with 32 hits and cartridges from a fifth loading packet partly introduced into magazine.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The 10 shots as a single-loader in twenty seconds; the magazine turned on, and its 10 shots fired in twelve seconds; total, thirty-two seconds.

(*b*) *As single-loader for one minute.*—Thirty-one shots were fired. In one instance the point of the bullet did not fairly enter the chamber, causing a jam.

(*c*) *As magazine arm for one minute.*—After the 10 cartridges from one loading packet had been introduced into the magazine and fired therefrom in fourteen seconds the operator inadvertently so far moved the cut-off as to partly close the mouth of the magazine, preventing the insertion of the cartridges from the second packet. Repeating the test, the 10 cartridges from the first loading packet were inserted and fired in twenty seconds, the inadvertent movement of the cut-off, which occurred twice as before, somewhat prolonging the time of firing. On the third trial 34 shots were fired and 6 cartridges left in the magazine.

III.—*Endurance.*

(*a*) *As a magazine arm for 500 rounds.*—Mechanism worked fairly well, but as test progressed, with increasing stiffness, requiring exertion of some little force to compress mainspring and close the bolt.

(*b*) *As single-loader for 100 rounds.*—During latter portion of test bolt worked with increasing stiffness. Six misfires occurred, of which five exploded on second trial and one failed on third.

In five instances cartridge case ruptured about 0.5 inch from base, forward part being left in chamber when head was extracted. In two instances a jam occurred as cartridge was pushed into chamber, probably occasioned by operator dropping cartridge in receiver so close to bolthead that it did not fall fairly in front of bolt, and the presence of the second extractor prevented its readily taking the proper position.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Fairly well dusted, mechanism of bolt worked with considerable difficulty, cut-off hard to move, difficult to push all the cartridges into magazine, and light blows from mallet required to operate cut-off, to close magazine after it was loaded.

(*b*) *Magazine loaded when exposed.*—Well dusted; before firing mechanism worked stiffly. In manipulating bolt to unload magazine the feed spring failed in two instances to bring up cartridge until after several trials. After recharging magazine, which required exertion of

considerable force, the cut-off could be closed only by blows from a mallet, a second operator meanwhile with a drift forcing the cartridges into magazine. Upon firing it was necessary for operator to grasp handle with both hands (gun in fixed rest) and to exert much strength before it could be unlocked. There were two missfires; both went on second trial.

One cartridge case ruptured; head brought out by extractor.

V.—*Defective cartridges.*

Board passed over this test, intending first to conduct following test:

VI.—*Excessive charges.*

After first shot repeated blows from a mallet required to unlock bolt and additional blows to subsequently retract it. Cartridge case ruptured.

In loading for second shot bolt worked very stiffly. After second shot use of a mallet necessary as before to unlock and operate bolt, which was only moved with great difficulty. Cartridge case ruptured. Shank of cartridge stop on outer surface of barrel partly lifted from its seat.

Remainder of test suspended.

VII.—*Ease of manipulation.*

Manipulation throughout trial difficult. Mechanism not suited for the military service.

No. 7.—Durst No. 4.

SAFETY TEST.

The gun was operated by M. H. Durst, the inventor.

After the first shot, in extracting the empty shell, the case was torn apart about 0.5 inch from the base, withdrawing the rear portion and leaving the forward portion in the bore of the piece.

Gun then withdrawn by inventor.

No. 8.—Blake No. 1.

SAFETY TEST.

The gun was operated by the inventor, Mr. John H. Blake, and fired from the shoulder, as a single-loader, 10 shots in forty-four seconds. One missfire; exploded on second trial.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being seven cartridges, it was endeavored to first fire 13 shots as a single-loader and then the 7 from the magazine. On the first trial the shock of discharge of the first

shot partly threw on the cut-off, enough to bring the head of the upper cartridge from the magazine in front of the bolt, causing, with the cartridge being loaded as a single-loader, a complete jam.

On second trial this again occurred exactly as before. It was then discovered that inventor in assembling gun had omitted a screw whose head served as a friction spring to restrict the free motion of the cut-off lever. Screw then replaced.

On third trial this again occurred, exactly as before, after the second shot had been fired. Gun then returned to inventor, who filed face of shoulder upon which cut-off lever rested.

On fourth trial, after 13 shots had been fired as a single-loader in 64 seconds, with 13 hits, the operator withdrew the bolt to eject the empty shell and then turned on the magazine. Upon endeavoring to close the bolt to continue the firing, it was found impossible to do so; inventor then explained that the system contemplated movement of the cut-off only when the bolt was entirely or partly closed. There were four failures to eject; one misfire went on second trial.

On fifth trial the 13 shots as single-loader were fired in forty-nine seconds; magazine turned on and its 7 cartridges fired in twenty-six seconds; total, one minute and fifteen seconds. Two misfires, 16 hits. There were 5 failures to eject.

During all this firing the mechanism worked with extreme difficulty, sharp blows from the hand upon the bolt handle being necessary to complete the locking and to move the bolt after firing.

(*b*) *As single-loader for two minutes.*—Using the gun as single-loader only, in consequence of the absence of the magazine packet and the cut-off being back of the receiver, there is no receiver floor for the cartridges, which, therefore, must be fully inserted into chamber before moving the bolt. Sixteen shots were fired and one cartridge left in chamber; 14 hits. Two misfires went on second trial. One failure to eject. Mechanism worked with extreme difficulty, blows from the hand being constantly required, as in preceding test.

(*c*) *As magazine arm for two minutes.*—On first trial, after loading magazine, the bolt having previously been drawn back, it was found impossible to operate mechanism. Inventor then explained that the system contemplated the charging of the magazine only when the bolt was closed. Conducting the test in this restricted manner, 19 shots were fired, of which two were misfires; 15 hits. There were 6 failures to eject and 2 failures to feed from the magazine until bolt had been several times moved back and forth. Mechanism operated with extreme difficulty, blows from operator, or of the bolt handle upon a table close at hand, being necessary after nearly each shot.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—Test omitted.

(*b*) *As single-loader for one minute.*—Test omitted.

(*c*) *As magazine arm for one minute.*—Test omitted.

III.—*Endurance.*

(*a*) *As magazine arm for 500 rounds.*—Test omitted.

(*b*) *As single-loader for 100 rounds.*—Test omitted.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Test omitted.

(*b*) *Magazine loaded when exposed.*—Test omitted.

V.—*Defective cartridges.*

Test omitted.

VI.—*Excessive charges.*

Test omitted.

VII.—*Ease of manipulation.*

Mechanism operated only with much difficulty. System entirely unsuited to the military service.

No. 9.—Russell-Livermore No. 1.

SAFETY TEST.

The gun was operated by the recorder of the board and fired from the shoulder, as a single loader, 10 shots in thirty-six seconds.

Bolt bound after each shot, and was moved with difficulty.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 5 shots, 15 shots were first fired as a single-loader in fifty-five seconds, the magazine turned on and its five cartridges fired in sixteen seconds; total for the 20 shots, one minute and eleven seconds; 19 hits.

Bolt bound after each shot; mechanism required considerable exertion of force to operate.

(*b*) *As single-loader for two minutes.*—Thirty-two shots were fired, with 31 hits and two cartridges fumbled and dropped by operator.

Bolt bound after each shot; mechanism required considerable exertion of force to operate.

(*c*) *As magazine arm for two minutes.*—Test omitted.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—Test omitted.

(*b*) *As single loader for one minute.*—Test omitted.

(*c*) *As magazine arm for one minute.*—Test omitted.

III.—*Endurance.*

(*a*) *As a magazine arm for 500 rounds.*—Test omitted.

(*b*) *As single-loader for 100 rounds.*—Test omitted.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Test omitted.

(*b*) *Magazine loaded when exposed.*—Test omitted.

V.—*Defective cartridges.*

Test omitted.

VI.—*Excessive charges.*

Test omitted.

VII.—*Ease of manipulation.*

Bolt mechanism not easy to operate. Magazine system not well adapted to the military service.

No. 10.—Russell-Livermore No. 2.

SAFETY TEST.

The gun was operated by the recorder of the board and fired from the shoulder, as a single-loader, 10 shots in thirty-seven seconds.

Bolt bound after each shot, and was moved with difficulty.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 5 cartridges it was endeavored to fire 15 shots as single-loader and then 5 from the magazine.

On first trial, after 9 shots had been fired in forty seconds, with 7 hits, a cartridge was used having no powder charge; bullet, consequently, driven into barrel by explosion of primer.

On second trial, after 7 shots had been fired in thirty seconds, with 6 hits, the eighth cartridge jammed as it was entering the chamber, binding against and scoring into the case of the upper cartridge in the magazine, which had risen above its proper place.

This upper cartridge was then replaced.

On third trial, after 10 shots had been fired in forty-two seconds, with 10 hits, the eleventh cartridge jammed in the same manner and from the same cause as above. Cartridge from magazine then replaced.

On fourth, fifth, and sixth trials, after a few shots had been fired in each instance, primer failed to ignite charge, bullet being driven into barrel. Considerable force always used to operate bolt, blows from a mallet being required in three instances.

(*b*) *As single-loader for two minutes.*—Test omitted.

(*c*) *As magazine arm for two minutes.*—On first and second trials after a few shots missfires occurred as above. On third trial the second cartridge jammed after it had passed from magazine into receiver and as bolt was pushing it towards chamber.

Considerable force always required to operate mechanism.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—Test omitted.

(*b*) *As single-loader for one minute.*—Test omitted.

(*c*) *As magazine arm for one minute.*—Test omitted.

III.—*Endurance.*

(*a*) *As a magazine arm for 500 rounds.*—Test omitted.

(*b*) *As single loader for 100 rounds.*—Test omitted.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Test omitted.
(*b*) *Magazine loaded when exposed.*—Test omitted.

V.—*Defective cartridges.*

Test omitted.

VI.—*Excessive charges.*

Test omitted.

VII.—*Ease of manipulation.*

Bolt mechanism not easy to operate.
Magazine system unsuited to the military service.

No. 11.—Russell-Livermore No. 3.

SAFETY TEST.

The gun was operated by Maj. William R. Livermore, Corps of Engineers, U. S. Army, and fired from the shoulder, as a single-loader, 10 shots in fifty-eight seconds.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—It was contemplated by the inventors that the gun should have a cut-off, but it, not being completely adjusted to the arm, was removed before submitting the gun to the Board.

The magazine packet holding 11 cartridges, 9 shots were first fired as a single-loader in thirty-four seconds, the magazine then charged and the 11 shots from the packet fired in forty-eight seconds. Total, one minute and twenty-two seconds; 18 hits.

After the fourth shot from the magazine a jam occurred, produced by the entire packet so far rising in the magazine that its side lips were in front of the bolt, preventing movement of the latter. Packet adjusted by operator and firing continued.

(*b*) *As a single-loader for two minutes.*—The bolt mechanism being that of the Lee-Speed, Mark I, of England, and the Russell-Livermore magazine system being the only feature offered for trial, this test was omitted.

(*c*) *As magazine arm for two minutes.*—Twenty-one shots were fired, with 17 hits and one cartridge left in the magazine. There was one failure to feed from the magazine. Mechanism assisted by operator and firing continued.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—Test conducted as for corresponding portion of first regular test.

The 9 shots as a single-loader in twenty-six seconds, the magazine

charged and its 11 cartridges fired in forty-two seconds; total one minute and eight seconds. One failure to feed from magazine, mechanism assisted by operator and firing continued.

(*b*) *As single-loader for one minute.*—Test omitted.

(*c*) *As magazine arm for one minute.*—Twenty-two shots were fired.

III.—*Endurance.*

(*a*) *As a magazine arm for 500 rounds.*—Test omitted.

(*b*) *As single-loader for 100 rounds.*—Test omitted.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Test omitted.

(*b*) *Magazine loaded when exposed.*—Test omitted.

V.—*Defective cartridges.*

Test omitted.

VI.—*Excessive charges.*

Test omitted.

VII.—*Ease of manipulation.*

Magazine system entirely unsuited to the military service.

No. 12.—WHITE.

SAFETY TEST.

The gun was operated by Lieut. H. K. White, Marine Corps, U. S. Navy, and fired from the shoulder, as a single-loader, 10 shots in twenty-five seconds.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being 5 cartridges it was endeavored to first fire 15 shots as a single-loader. After the first shot the second cartridge which had been placed by the operator in the receiver, jammed when pushed forward by the bolt, the point of the bullet striking against the right-hand side of the face of the end of the barrel, instead of entering the chamber; slightly withdrawing the bolt released the cartridge which could then be entirely pushed forward.

For the third shot, the cartridge entered the chamber, but it was impossible to entirely close the operating slide of the bolt. On examination it was discovered that the point of the left-hand prong of the slide had been broken and the detached piece fallen into the mechanism.

Test then suspended, and gun withdrawn by Lieut. White for repairs.

Ten days later, the repairs having been completed, the gun was again brought before the board and the test resumed in the presence of Lieut. White and Mr. A. D. Andrews, counsel for the White Magazine Rifle Company.

Repeating test (*a*), the 15 shots as a single-loader were fired in forty-one seconds, the magazine turned on and its 5 cartridges fired in ten seconds; total. fifty-one seconds; 17 hits.

(*b*) *As a single-loader for two minutes.*—On first trial after 16 shots had been fired in fifty-five seconds with 15 hits and one other cartridge partly introduced in chamber, the bolt could not be entirely closed. After test was suspended, on further trial, operator succeeded in closing bolt.

On second trial 39 shots were fired with 38 hits. After test had been about one-third conducted mechanism commenced to work more stiffly, still later on considerable exertion required in five instances to open bolt.

(*c*) *As magazine arm for two minutes.*—On first trial after the first shot operator was unable to close bolt when feeding in the second cartridge from the magazine.

On second trial this again occurred with the fourth cartridge from the magazine.

On third trial after one shot had been fired the point of the bullet of the second cartridge from the magazine caught in the extractor cut in face of barrel (instead of entering the chamber), causing a jam.

On fourth trial, after one shot, a jam again occurred with the second cartridge from the magazine in the same manner as before.

On fifth trial, after 18 shots had been fired with 18 hits in fifty seconds, the next cartridge, the fourth from the packet then in the magazine, jammed in extractor cut in same manner as before.

On sixth trial, after 5 shots had been fired with 5 hits in ten seconds, operator could not close bolt upon the sixth cartridge.

On seventh trial, after 31 shots had been fired with 31 hits in one minute and twenty-nine seconds, the next cartridge, the second from the packet then in the magazine, was not fully fed up into the receiver, the bolt in its motion then overriding the head jammed against the side of the case at the neck.

On eighth trial, after 16 shots had been fired, with 15 hits, in forty seconds, the next cartridge, the second from the packet then in the magazine, jammed in exactly the same manner as in the immediately preceding trial.

On ninth trial, after 21 shots had been fired, with 19 hits, in fifty seconds, the point of the bullet of the next cartridge, the second from the packet then in the magazine, entered the extractor cut instead of the chamber and caused a jam.

On tenth trial, after 6 shots had been fired, with 6 hits, in fifteen seconds, a jam occurred with the next cartridge, the second from the packet then in the magazine, in the same manner as in the seventh and eighth trials.

On eleventh trial the second cartridge from the magazine caused a jam as in the immediately preceding trial.

On twelfth trial, after 23 shots had been fired, with 21 hits, in sixty seconds, the point of the bullet of the next cartridge, the fourth from the packet then in the magazine, jammed against the face of the barrel as in the third, fourth, fifth, and ninth trials.

On thirteenth trial, after 6 shots had been fired, with 4 hits, in fifteen seconds, a similar jam again occurred with the next cartridge, the second from the packet then in the magazine.

On fourteenth trial, after 26 shots had been fired, with 21 hits, in sixty-two seconds, a similar jam again occurred with the next cartridge, the second from the packet then in the magazine.

On fifteenth trial, 25 shots were fired, with 25 hits, and one cartridge left in chamber. During the firing there were three jams, two occasioned by point of bullet striking face of barrel at extractor cut, and one by failure of cartridge to fully rise in front of bolt. In the first instance operator drew back the bolt, and pushing with the fingers the cartridge into place, continued the firing; in the other instance it was necessary to remove the packet (from which two cartridges had been fired) when endeavoring to overcome the jam.

One other packet, after 2 shots had been fired from it, worked free from the retaining catch, and rising into receiver in front of the bolt, was pushed back into place by operator. During these successive trials, if continued for more than a few shots, the mechanism commenced to work stiffly, considerable exertion being required in a number of instances to both close and open bolt.

II.—*Rapidity at will.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The 15 shots as a single-loader were fired in thirty-seven seconds, the magazine then turned on and its five cartridges fired in eleven seconds; total, forty-eight seconds. Necessary in one instance, after attempting to close bolt, to partly withdraw it and then force it home strongly. Considerable exertion required in four instances to open bolt.

(*b*) *As single-loader for one minute.*—Twenty-seven shots were fired and one other cartridge fumbled and dropped by operator. The extra motion to close bolt once required, and considerable exertion to open bolt three times.

(*c*) *As magazine arm for one minute.*—Thirty-two shots were fired; extra motion to close bolt necessary five times. As test progressed mechanism worked with greater stiffness, considerable force being also required to open bolt.

During all the preceding trials the empty shells were so ejected as to frequently hit the operator in the face with force.

III.—*Endurance.*

(*a*) *As magazine arm for 500 rounds.*—Test conducted according to usual manner, in sets of 50 shots; after each set barrel cooled. Toward the latter portion of each set of 50, mechanism commenced to work stiffly, considerable force being frequently required both to close and open bolt.

In closing bolt for the eighty-eighth shot, operator pushed down cut-off, shutting off the magazine; discovered by the failure of the next cartridge to feed, and corrected. This occurred a second time later on in the trial.

After about the two hundred and fiftieth round misfires commenced to occur, until after the three hundred and seventy-eighth shot (when there had been 13 misfires) the striker failed entirely after repeated trials to reach the cartridge.

Removing and dismounting bolt, it was found that the firing pin had in its motion produced a burr on the inner face of the interior bolt cover, which prevented the full action of the pin.

Gun withdrawn and burr removed in a few minutes by inventor. Resuming test, there were no more misfires until near conclusion of the five hundred rounds, when three occurred.

(*b*) *As single-loader for 100 rounds.*—Mechanism worked with increasing stiffness near conclusion of each set of 50 shots. There were 6 misfires.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Well dusted; mechanism worked very stiffly.

(*b*) *Magazine loaded when exposed.*—Well dusted; bolt worked very hard both in opening and closing.

V.—*Defective cartridges.*

Test passed over with the intention of first conducting Test VI.

VI.—*Excessive charges.*

After the first shot the bolt was opened only with extreme difficulty, it being necessary for the operator (the gun being in the fixed rest) to grasp the handle with both hands and pull back with all the force he could apply.

After the second shot the same measures were necessary to open the bolt.

By the third shot it was evident that the cartridge was not well supported by the bolt and that the cartridge case had ruptured.

The escaping gas broke the stock at either side of the receiver and magazine cut, blowing out the left-hand piece. The follower spring and its guiding bar were also blown out of the magazine.

By no force that the operator could exert, even when aided by blows from a mallet, could the bolt be opened.

Subsequently, after immersion in kerosene oil, the bolt was opened, when the following parts were found to be in the condition stated:

Bolt cracked in two places, on right-hand lower side, at front and rear of channel for locking block.

Handle badly cracked at its junction with the bolt; became separated when endeavoring to maneuver bolt.

Upper part of left wall of receiver bent upward.

Locking shoulders on right and left sides of receiver considerably upset.

Magazine spring bent out of shape.

Follower spring bent out of shape and part of it broken.

Rib containing guide way in right-hand side of magazine box bent.

Both sides of box bulged out.

Rivets securing sides to bottom of box started.

Stock, bolt mechanism, and magazine mechanism entirely unserviceable.

VII.—*Ease of manipulation.*

The straight pull considered by the board a disadvantage.

Method of locking bolt not approved. Bolt mechanism easy to operate when cool and clean; difficult as gun becomes foul.

System of insufficient strength.

Magazine mechanism uncertain and unsatisfactory in action.

System generally not suited to the military service.

No. 13.—Hampden.

SAFETY TEST.

The gun was operated by the inventor, Mr. Thomas B. Wilson, of East Boston, Mass., and fired from the shoulder as a single-loader 10 shots in thirty-eight seconds. One misfire exploded on second trial.

REGULAR TESTS.

I.—*Rapidity with accuracy.*

(*a*) *As single-loader and then as repeating arm for contents of magazine.*—The capacity of the magazine being five cartridges, 15 shots were first fired as a single-loader in forty-three seconds, the magazine then turned on and its five cartridges fired in twelve seconds, total fifty-five seconds; 20 hits. One misfire went on second trial. Operator twice hit in face by ejected shells.

(*b*) *As single-loader for two minutes.*—Forty-seven shots were fired. There were two misfires, one went on second trial, the other ejected into neighboring pond and could not be recovered. Thirty hits.

(*c*) *As magazine arm for two minutes.*—Thirty-nine shots were fired, and one cartridge remaining in chamber.

One misfire exploded on second trial. Thirty-two hits. In two instances cartridges were not readily stripped by operator from the loading packet to their proper positions in magazine.

II.—*Rapidity at will.*

(*a*) *As single loader and then as repeating arm for contents of magazine.*—The 15 shots as single loader in thirty seconds, the magazine turned on and its 5 cartridges fired in six seconds, total thirty-six seconds. One misfire exploded on second trial.

(*b*) *As single loader for one minute.*—Twenty-eight shots were fired. Three being misfires, exploded on second trial.

(*c*) *As magazine arm for one minute.*—Twenty-two shots were fired; one, being a misfire, went on third trial. In two instances operator failed to properly strip cartridges from loading packet to their proper place in magazine, one cartridge falling to the ground in one case, two cartridges falling out in the other instance.

III.—*Endurance.*

(*a*) *As magazine arm for 500 rounds.*—There were during the 500 rounds 30 misfires, of which 27 exploded on second and 3 on third trial.

There were 17 failures to extract, the claw of the extractor overriding the cartridge head and leaving the empty case in the chamber. There were 8 failures to feed, the last cartridge in the magazine in each instance jumping up and when falling back either turning completely over, bullet for head, or falling back at such an angle that it could not be reached by the bolt or issue through the magazine opening. There was one jam, point of bullet striking against right face of barrel instead of entering chamber as it was driven forward by the bolt.

In charging magazine from the loading packet much care was requisite to properly strip the cartridges, in a number of instances independent adjustment of the cartridges being necessary, the operator frequently using both hands. In this, as in all the preceding and following tests, the ejector threw the empty shell either directly at or close to the operator's face.

With exceptions mentioned, bolt mechanism worked smoothly and easily.

(*b*) *As single loader for 100 rounds.*—On third shot the jar of recoil had so far opened magazine gate as to permit the upper cartridge from magazine to jump out and fall to the floor. Cartridge replaced and gate reclosed. This again occurred on the fifth shot; cartridge again

replaced and gate reclosed. Throughout remainder of the 100 rounds this recurred at intervals of about two or three shots, happening in all forty times; in 33 instances only the upper cartridge jumped out; in 7 other instances the upper two cartridges jumped out. There were 6 misfires, went on second trial. There were 21 failures to extract, extractor overriding the head and leaving the empty case in the chamber. There was one failure to eject.

In 13 instances the shock of discharge turned on the cut-off, permitting the lower cartridge from the reserve supply to issue in front of the bolt.

After the fifty-second shot it was observed that this defect was probably occasioned by the loosening of the retaining screw of the cut-off slide; tightening this screw the slide was retained in place until near the close of the trial, when the defect again occurred on the ninety-fourth shot. During this test it was observed that operating the cut-off when the magazine was charged with any number of cartridges from one to five, its full contents, the magazine was not placed in reserve, the lower cartridge being so left that the bolt would carry it into the chamber. Pushing back this cartridge with one hand and at the same time operating the cut-off with the other, the magazine could be placed in reserve.

With the exceptions noted the bolt mechanism worked smoothly and easily.

IV.—*Dust.*

(*a*) *Magazine empty when exposed.*—Well dusted. Magazine gate opened with difficulty. By the second shot as single loader the shock of discharge again turned on magazine as in former test. There were 3 misfires went on second trial. There were 4 failures to extract. Cut-off moved, to turn on magazine, only with much difficulty.

(*b*) *Magazine loaded when exposed.*—Well dusted. Magazine gate operated only with much difficulty.

There were 3 misfires· exploded on second trial and 5 failures to extract. On completion of single-loading fire magazine cut-off could be moved only by light blows from a mallet.

With exceptions noted, bolt mechanism worked smoothly and easily.

V.—*Defective cartridges.*

This test was applied by the board after that for excessive charges given below.

No injury whatever to bolt or magazine mechanism from the different defectives. Bolt mechanism worked smoothly and easily.

VI.—*Excessive charges.*

This test was applied by the board before that for defective cartridges given above.

With each of the 5 shots the extractor failed to bring out the empty shell. Otherwise bolt mechanism worked smoothly and easily.

VII.—*Ease of manipulation.*

Bolt mechanism always easy to work, but extractor not properly held down over cartridge head.

Magazine mechanism difficult to operate when gun is dusty. The principle of gravity feed from magazine to receiver, as applied in this system, a failure. The cut-off also a failure.

Magazine system not suited to the military service.

No. 14 Blake No. 2.

The system being identical with the Blake No. 1, already found (see synopsis of tests of Blake No. 1) to be "entirely unsuited to the military service," the board, after the examination required by its instructions (see letter of the Secretary of War in the proceedings of the board for April 18, 1893), concluded that this present arm did not "possess sufficient merit to warrant the expense of a trial," and therefore that they were not authorized to proceed with any test.

It was also again concluded that this Blake No. 2 and the system it represents is entirely unsuited to the military service.

Table showing weight, capacity of magazine, and results of test of each magazine arm before the board.

Number on docket.	Name of gun.	Type of magazine.	Cartridges in magazines.	Weight without bayonet.		Weight of ammunition.			Complete cartridge.		Muzzle velocity.	Caliber of gun.	Safety test.		
				With magazine empty.	With magazine full.	Bullet.	Powder.	Complete cartridge.	Lengths.	Diameter across head.			Time.	Misfires.	Remarks.
				Lbs. Oz.	*Lbs. Oz.*	*Grs.*	*Grs.*	*Grs.*	*Inches.*	*Inch.*	*Feet.*	*Inch.*	*Secs.*		
1	Spencer-Lee	Central, vertical, detachable.	5	10 0	10 11	405	70	645	2.560	0.610	1,350	0.450	.....	....	Not tested.
2	Lee, model 1893	Central, vertical	10	8 2	8 13	230	37	420	3.090	.541	2,000	.300	32	....	Fired by Mr. J. P. Lee.
3	Savage	Central, revolving cylinder.	9	10 4	10 12	230	37	420	3.090	.541	2,000	.300	25	....	Fired by Mr. Arthur Savage.
4	Durst, No. 1	Central, cylindrical	10	.....	.....	216	.....	.....	3.049	.460	.....	.303	.....	....	Not tested.
5	Durst, No. 2	Same as Durst, No. 1	10	.....	.....	216	.....	.....	3.049	.460	.....	.303	45	....	Fired by Mr. M. H. Durst.
6	Durst, No. 3	.....do	10	9 4	9 14	230	36	420	3.090	.458	1,960	.300	29	....	Do.
7	Durst, No. 4	.....do	10	.....	.....	230	36	420	3.090	.458	1,960	.300	.....	....	Only one shot of safety test fired.
8	Blake, No. 1	Central, revolving cartridge packet.	7	9 10	10 3	230	37	420	3.090	.541	2,000	.300	44	1	Fired by Mr. John H. Blake.
9	Russell-Livermore, No. 1.	Central, vertical	5	9 0	9 5	214	40	408	3.052	.525	1,935	.303	36	....	Fired by the recorder.
10	Russell-Livermore, No. 2.	Central, almost horizontal	5	9 10	9 15	214	40	408	3.052	.525	1,935	.303	37	....	Do.
11	Russell-Livermore, No. 3.	Central, vertical	11	9 8	10 3	230	37	420	3.090	.541	2,000	.300	58	....	Fired by Maj. W. R. Livermore.
12	White	.....do	5	8 15	9 4	230	37	420	3.090	.541	2,000	.300	25	....	Fired by Lieut. H. K. White.
13	Hampden	Central, vertical, over left of receiver.	5	8 3	8 8	230	37	420	3.090	.541	2,000	.300	38	1	Fired by Mr. Thomas B. Wilson.
14	Blake, No. 2	Central, revolving cartridge packet.	7	9 10	10 3	230	37	420	3.090	.541	2,000	.300	.....	...	Not tested.

REGULAR TESTS.

Number on docket.	Name of gun.	I.—Rapidity with accuracy.														
		a. For 20 shots.					*b.* As single loader for two minutes.					*c.* As magazine gun for two minutes.				
		Shots as single loader.	Shots from magazine.	Hits.	Time.	Remarks.	Shots.	Hits.	Misfires.	Remaining in chamber.	Remarks.	Shots.	Hits.	Misfires.	Remaining in magazine.	Remarks.
					Sec.											
1	Spencer-Lee	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
2	Lee, model 1893	10	10	20	55	Second trial. On first trial three failures to feed; one partial and one complete jam. One failure to eject.	38	37	....	....	Necessary to fully insert cartridge in chamber with fingers.	51	49	....	9	Second trial, two partial jams. On first trial a complete jam occurred.
3	Savage	12	8	15	58	Twenty seconds for shots from magazine.	33	29	2	....	Operator failed three times on first motion to entirely close bolt.	30	19	....	....	Magazine charged from packets holding six cartridges.
4	Durst, No. 1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
5	Durst, No. 2	10	10	20	126	Bolt moved with great difficulty. Blows from mallet required in three instances.	....	....	....	....	....	....	....	....	....	
6	Durst, No. 3	10	10	20	50	Twenty-two seconds for shots from magazine.	37	36	....	1	Three slight jams, bullet striking against face of barrel.	40	32	...	1	
7	Durst, No. 4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
8	Blake, No. 1	13	7	16*	75	Fifth trial, bolt worked with extreme difficulty.	16	14	2	1	Worked with extreme difficulty. Necessary to fully insert cartridge in chamber with fingers.	19	15	2	....	Two failures to feed from magazine. Six failures to eject. Mechanism operated with extreme difficulty.
9	Russell-Livermore, No. 1.	15	5	19	71	Considerable force required to operate mechanism.	32	31	....	....	Two cartridges fumbled and dropped by operator.	....	....	....	....	
10	Russell-Livermore, No. 2.	....	....	....	....	Test not completed	....	....	....	....	....	....	....	....	....	
11	Russell-Livermore, No. 3.	9	11	18	82	One jam; magazine packet rising in front of bolt.	....	....	....	....	Test omitted	21	17	....	1	One failure to feed from magazine.
12	White	15	5	17	51	Second trial	39	38	....	....	Second trial	25	25	....	....	Fifteenth trial, many jams, occasioned by failures to properly feed from magazine.
13	Hampden	15	5	20	55	Twelve seconds for shots from magazine.	47	30	2	....	Bolt worked easily	39	32	1	1	Cartridges, in two instances not readily loaded from packet to magazine.
14	Blake, No. 2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	

Table showing weight, capacity of magazine, and results of tests of each magazine arm before the board—Continued.

REGULAR TESTS—Continued.

Number on docket.	Name of gun.	II.—Rapidity at will.											
		a. For 20 shots.				*b.* As single loader for one minute.				*c.* As magazine gun for one minute.			
		Shots as single loader.	Shots from magazine.	Time.	Remarks.	Shots.	Misfires.	Remaining in chamber.	Remarks.	Shots.	Misfires.	Remaining in magazine.	Remarks.
				Sec.									
1	Spencer-Lee	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
2	Lee, model 1893	10	10	37	Twelve seconds for shots from magazine.	21	.....	1	Necessary to fully insert cartridges in chamber with fingers.	40	....	.....	
3	Savage	12	8	66	In three instances top cartridge from magazine rose into chamber.	20	1	.....	One failure to entirely close lever on first motion.	24	....	.....	Magazine partly filled each time with six cartridges.
4	Durst, No. 1	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
5	Durst, No. 2	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
6	Durst, No. 3	10	10	32	Twelve seconds for shots from magazine.	31	.....	.....	One slight jam, bullet not fairly entering chamber.	34	....	6	Third trial, magazine inadvertently cut off on first and second trials.
7	Durst, No. 4	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
8	Blake, No. 1	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
9	Russell-Livermore, No. 1	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
10	Russell-Livermore, No. 2	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	
11	Russell-Livermore, No. 3	9	11	68	One failure to feed from magazine	....	.....	.....	.....	.....	...	.....	
12	White	15	5	48	Considerable force required in four instances to open bolt.	27	.....	.....	Considerable force required in three instances to open bolt.	32	....	.....	As test progressed increased force required to open bolt.
13	Hampden	15	5	36	Six seconds for shots from magazine.	28	3	.....	Bolt worked easily.	22	1	.....	Difficulty experienced in properly loading magazine from cartridge packet.
14	Blake, No. 2	.....	.....	...	.....	...	.....	.....	.....	.....	...	.....	

REGULAR TESTS—Continued.

Number on docket.	Name of gun.	III.—Endurance.					
		a. As magazine gun.			*b.* As single-loader.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
1	Spencer-Lee						
2	Lee, model 1893	500		Four failures to feed properly from magazine. Eleven jams as cartridges were pushed into chamber. Considerable force required to close bolt. Bolt lifted, becoming nearly unlocked, after firing unless handle was held down by operator.	100		Bolt unlocked after each discharge whenever operator's hand was removed from handle.
3	Savage	500	3	Considerable force required to operate mechanism.	100		Considerable force required to operate mechanism.
4	Durst, No. 1						
5	Durst, No. 2						
6	Durst, No. 3	500		Worked with increasing stiffness as test progressed.	100	6	Bolt worked with increasing stiffness as test progressed. Five cartridge cases ruptured, leaving forward part in chamber. Two jams in loading.
7	Durst, No. 4						
8	Blake, No. 1						
9	Russell-Livermore, No. 1						
10	Russell-Livermore, No. 2						
11	Russell-Livermore, No. 3						
12	White	500	16	Worked with increasing stiffness as test progressed.	100	6	Bolt worked with increasing stiffness as test progressed.
13	Hampden	500	30	Seventeen failures to extract. Eight failures to properly feed from magazine. One jam.	100	6	Twenty-one failures to extract. In forty instances cartridges thrown out of magazine by shock of discharge, and in thirteen instances cut-off was moved, turning on the magazine.
14	Blake, No. 2						

Table showing weight, capacity of magazine, and results of test of each magazine arm before the board—Continued.

REGULAR TESTS—Continued.

Number on docket.	Name of gun.	IV.—Dust.					
		a. Magazine empty when exposed.			*b*. Magazine loaded when exposed.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
1	Spencer-Lee						
2	Lee, model 1893	20		Considerable force required to operate mechanism.	20		Great force required to operate mechanism. Blows from mallet needed in several instances.
3	Savage	20		Increased force required to charge magazine and to operate the mechanism.	20		Worked fairly well.
4	Durst, No. 1						
5	Durst, No. 2						
6	Durst, No. 3	20		Bolt worked with considerable difficulty. Much force required in charging magazine and blows from a mallet to then move cut-off.	20	2	Magazine feed-spring failed twice to bring up cartridges. Much force required to charge magazine and blows from a mallet to then move cut-off. Use of both hands and much strength required to open and move bolt after firing. One cartridge case ruptured.
7	Durst, No. 4						
8	Blake, No. 1						
9	Russell-Livermore, No. 1						
10	Russell-Livermore, No. 2						
11	Russell-Livermore, No. 3						
12	White	20		Mechanism worked very stiffly	20		Bolt worked very hard.
13	Hampden	20	3	Magazine gate opened with difficulty. Four failures to extract. Much difficulty experienced in moving cut-off to turn on magazine. Bolt mechanism operated easily.	20	3	Blows from a mallet required to operate cut-off. Bolt mechanism worked easily.
14	Blake, No. 2						

REGULAR TESTS—Continued.

Number on docket.	Name of gun.	V.—Defective cartridges.			VI.—Excessive charges.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
1	Spencer-Lee	.....	.....	.....	.....	.....	
2	Lee, model 1893	.....	.....	Test omitted at request of inventor	.....	.....	Test omitted at request of inventor.
3	Savage	2	.....	Extractor slightly sprung. Automatic cut-off broken, preventing use as magazine gun.	.....	.....	
4	Durst, No. 1	.....	.....	.....	.....	.....	
5	Durst, No. 2	.....	.....	.....	.....	.....	
6	Durst, No. 3	.....	.....	Board passed over this test, intending to first apply following test.	2	.....	After each shot repeated blows from mallet required to unlock bolt, and additional blows to subsequently retract it. Cartridge stop bent. Cartridge cases ruptured.
7	Durst, No. 4	.....	.....	.....	.....	.....	
8	Blake, No. 1	.....	.....	.....	.....	.....	
9	Russell-Livermore, No. 1	.....	.....	.....	.....	.....	
10	Russell-Livermore, No. 2	.....	.....	.....	.....	.....	
11	Russell-Livermore, No. 3	.....	.....	.....	.....	.....	
12	White	.....	.....	Board passed over this test, intending to first apply following test.	3	.....	Bolt opened only with extreme difficulty after first and second shots; could not be opened until next day after third shot. Several parts of mechanism broken.
13	Hampden	2	.....	Test conducted after that for "excessive charges." No injury whatever to mechanism. Bolt worked easily.	5	.....	Test conducted before that for "defective cartridges." Five failures to extract. Bolt opened and operated easily after each discharge.
14	Blake, No. 2	.....	.....	.....	.....	.....	

INDEX.

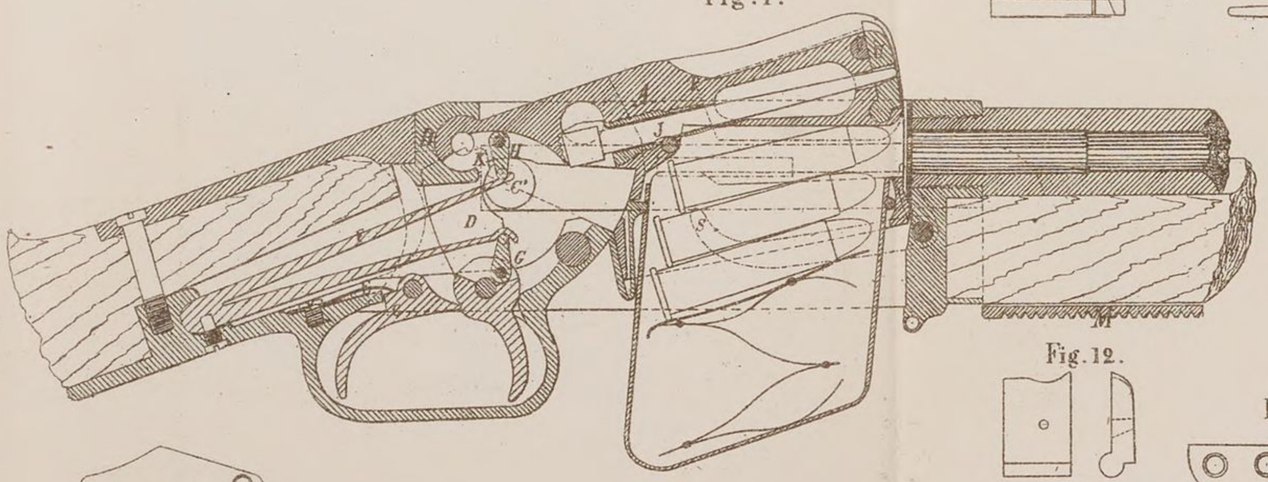
	Page.
ANDERSON, CAPT. GEORGE S., SIXTH CAVALRY:	
member of the board	132
relieved from the board	144
BANNERMAN, FRANCIS:	
submits the Spencer-Lee arm	138
BATES, COL. JOHN C., SECOND INFANTRY:	
member of the board	144
BLAKE, JOHN H.:	
submits the Blake arm (Nos. 1 and 2)	138
BLAKE ARM, No. 1:	
description (Plate v)	155
BLAKE ARM, No. 2:	
description	166
BLAKE ARM:	
report on the system, No. 1	130
report on the system, No. 2	131
synopsis of tests, No. 1	173
synopsis of tests, No. 2	184
tables of weight, capacity of magazine, and result of tests of Nos. 1 and 2.	185
BLUNT, CAPT. S. E., ORDNANCE DEPARTMENT, U. S. A.:	
member and recorder of board	132
BOARD OF ORDNANCE AND FORTIFICATION:	
transmits to Secretary of War the report of the Board on Magazine Arms	127
BOARD ON MAGAZINE ARMS:	
submits to the Board of Ordnance and Fortification its report	128
DESCRIPTIONS OF THE MAGAZINE ARMS	148
DETAIL OF OFFICERS:	
for the Board on Magazine Arms	132
DURST, M. H.:	
submits Durst arms, Nos. 1, 2, 3, and 4	138
DURST ARM:	
description (Plate iv), No. 1	151
description, Nos. 2, 3, and 4	155
report of the board on the system	130
synopsis of tests	171
table of weights, capacity of magazine, and result of tests, etc	185
EXTENSION OF TIME:	
to May 1, 1893, for presentation of arms	143
FARLEY, LIEUT. COL., ORDNANCE DEPARTMENT, U. S. A.:	
member of the board	132
relieved from the board	144
FREEMAN, MAJ. HENRY B., SIXTEENTH INFANTRY:	
member of the board	132
HALL, LIEUT. R. H., SIXTH INFANTRY:	
member of the board	132
HAMPDEN ARM:	
submitted by T. B. Wilson	138
description (Plate viii)	160
report of the board on the system	131
synopsis of tests	181
tables of weights, capacity of magazine, and result of tests, etc	185
INVENTORS:	
will be supplied at cost price with parts of any arm, or of amunition made by the Government	133
may present arms of caliber other than .30	137

	Page.
LEE, J. P.:	
submits Lee arm, model 1893	138
LEE ARM, MODEL 1893:	
description (Plate II)	150
report of the board on the system	129
synopsis of tests	167
table of weight, capacity of magazine, and result of tests, etc	185
LIST OF ARMS SUBMITTED	147
LIVERMORE, MAJ. W R., CORPS OF ENGINEERS, U. S. A.:	
submits Russell-Livermore arm (1, 2, and 3)	138
MOORE, MAJ. FRANCIS, FIFTH CAVALRY:	
member of board	144
OPINION OF THE BOARD:	
upon the requirements of the arm best adapted for the U. S. service	128
OTIS, COL. ELWELL S., TWENTIETH INFANTRY:	
member of the board and president thereof	132
PROCEEDINGS OF THE BOARD (Part I)	132
REPORT OF THE BOARD:	
on the systems presented	129
REQUISITES:	
of the arm best adapted for service	128
RULES AND TESTS (*see* Tests):	
for examination and trials of guns, etc	133
RUSSELL-LIVERMORE ARM:	
Nos. 1, 2, and 3 submitted by Maj. W. R. Livermore, U. S. A	138
description (Plate VI)	158
report of the board on the system	130
synopsis of tests	175
table of weight, capacity of magazine, and result of tests, etc	185
SALES:	
of parts of any arm and of ammunition authorized to be made to inventors	133
SAVAGE, ARTHUR:	
submits the Savage arm	138
SAVAGE ARM:	
description (Plate III)	150
report of the board on the system	129
synopsis of tests	169
table of weight, capacity of magazine, and result of tests, etc	185
SCHOFIELD, MAJ. GEN. J. M.:	
transmits to the Secretary of War the report of the Board on Magazine Arms	127
SPENCER-LEE ARM:	
submitted by Francis Bannerman	138
description (Plate I)	148
report of the board on the system	129
synopsis of tests	167
table of weight, capacity of magazine, and results of test, etc	185
SYSTEMS OF THE ARMS SUBMITTED:	
report of the board	129
TESTS AND RULES:	
governing examination and trials of arms	133
arms other than caliber .30 may be tested	137
all arms to be submitted before March 31, 1893	137
time for submitting arms extended to May 1, 1893	143
WHITE, LIEUT. H. R., U. S. MARINE CORPS:	
submits White arm	138
WHITE ARM:	
description (Plate VII)	160
report of the board on the system	130
synopsis of tests	178
table of weight, capacity of magazine, and result of tests, etc	185
WILSON, T. B.:	
submits the Hampden arm	138

NO 1.
SPENCER-LEE

PLATE I.

Fig. 1.



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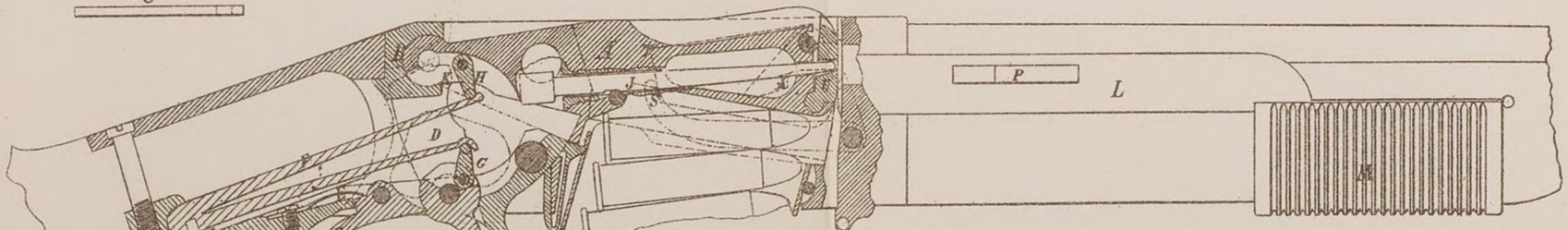

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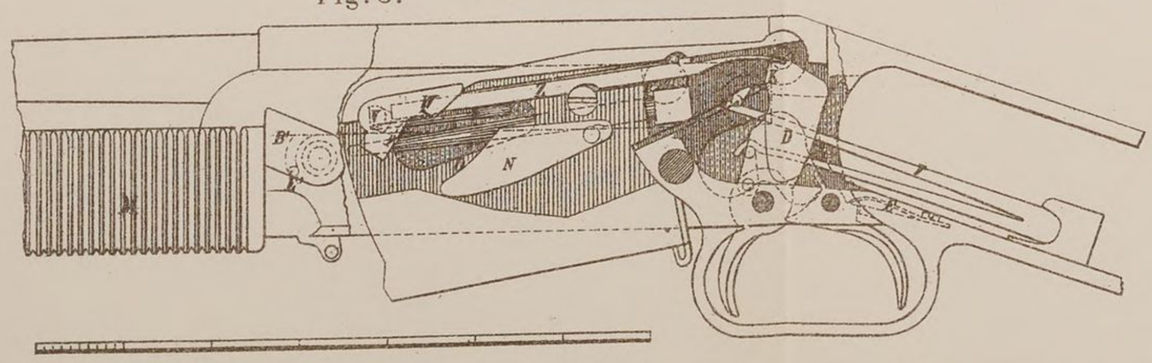

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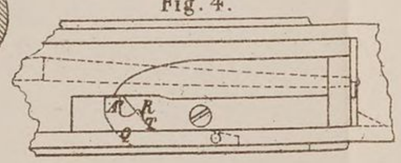

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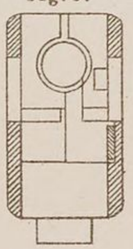

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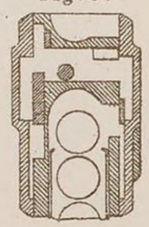

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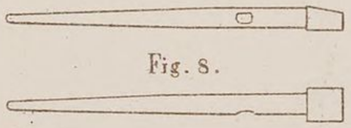

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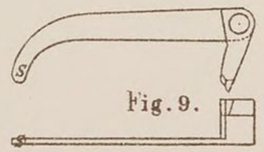

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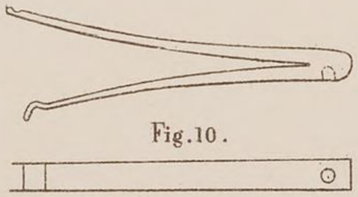

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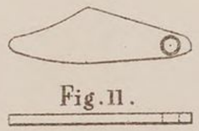

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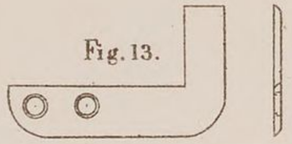

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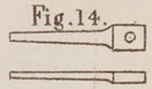

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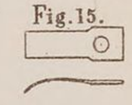

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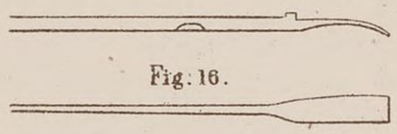

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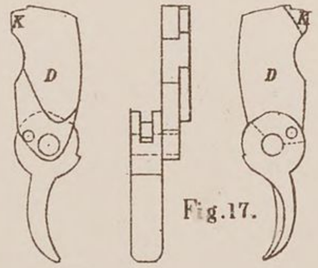

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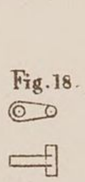

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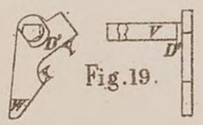

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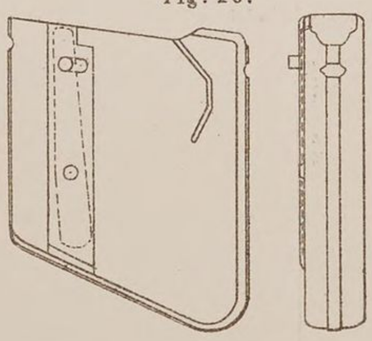

Fig. 21.

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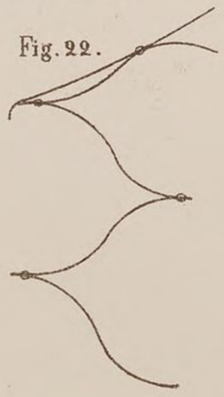

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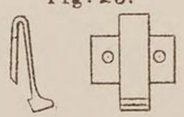

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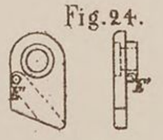
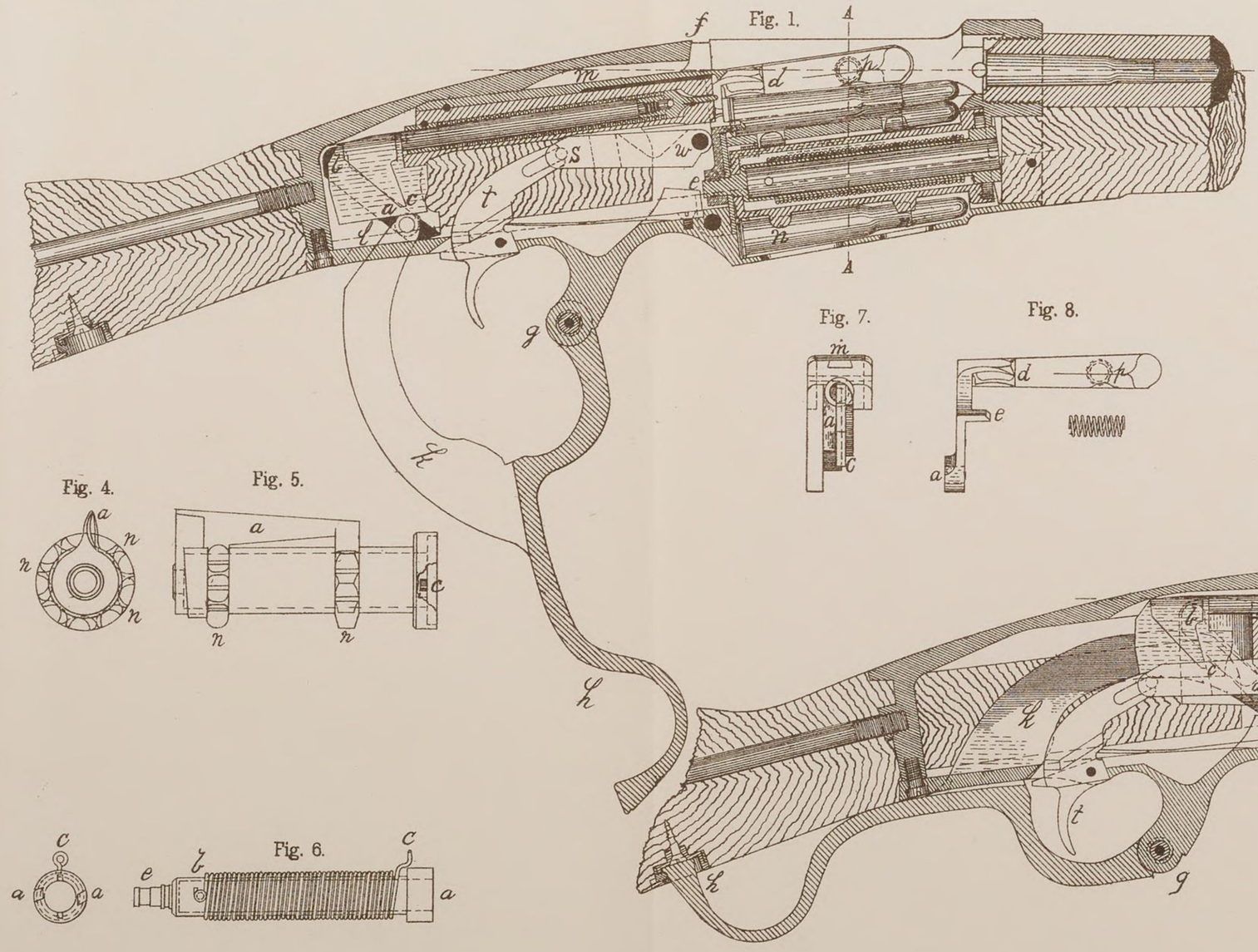


Ord 53 2

NO. 3.
SAVAGE.

PLATE III.

Fig. 1.



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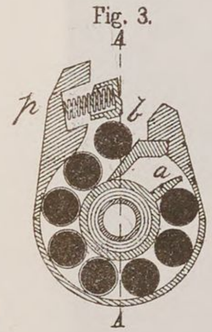

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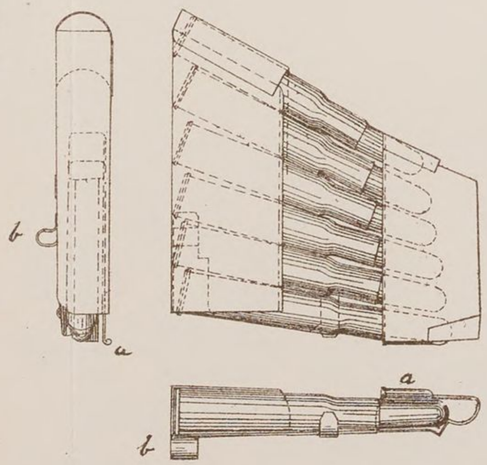


Fig. 7.

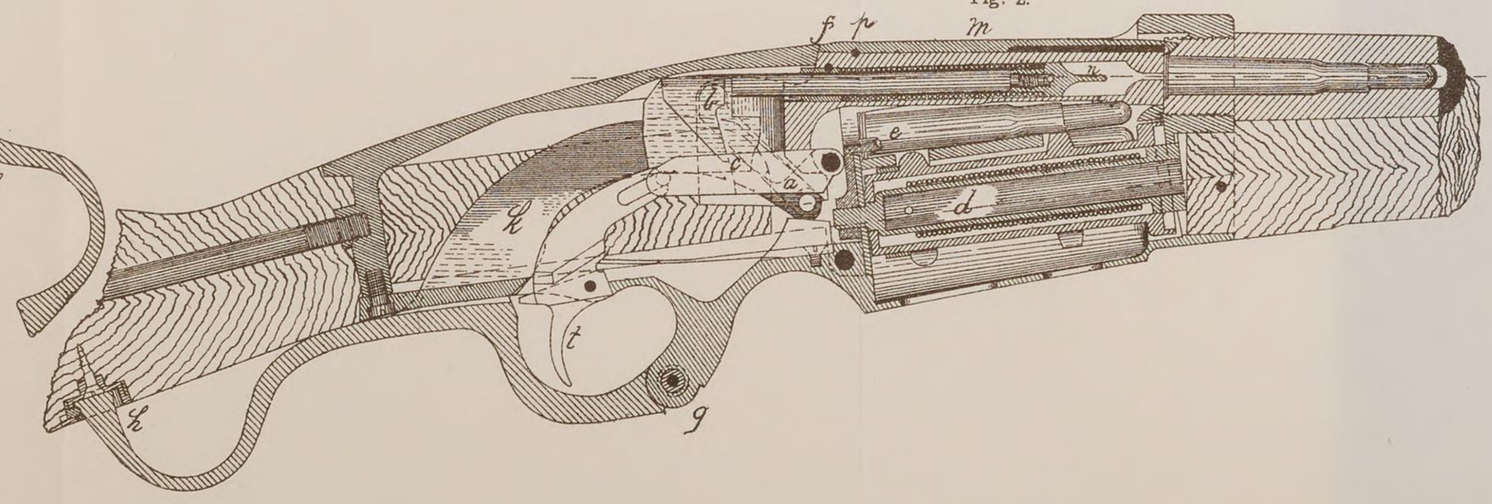
Fig. 8.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 2.

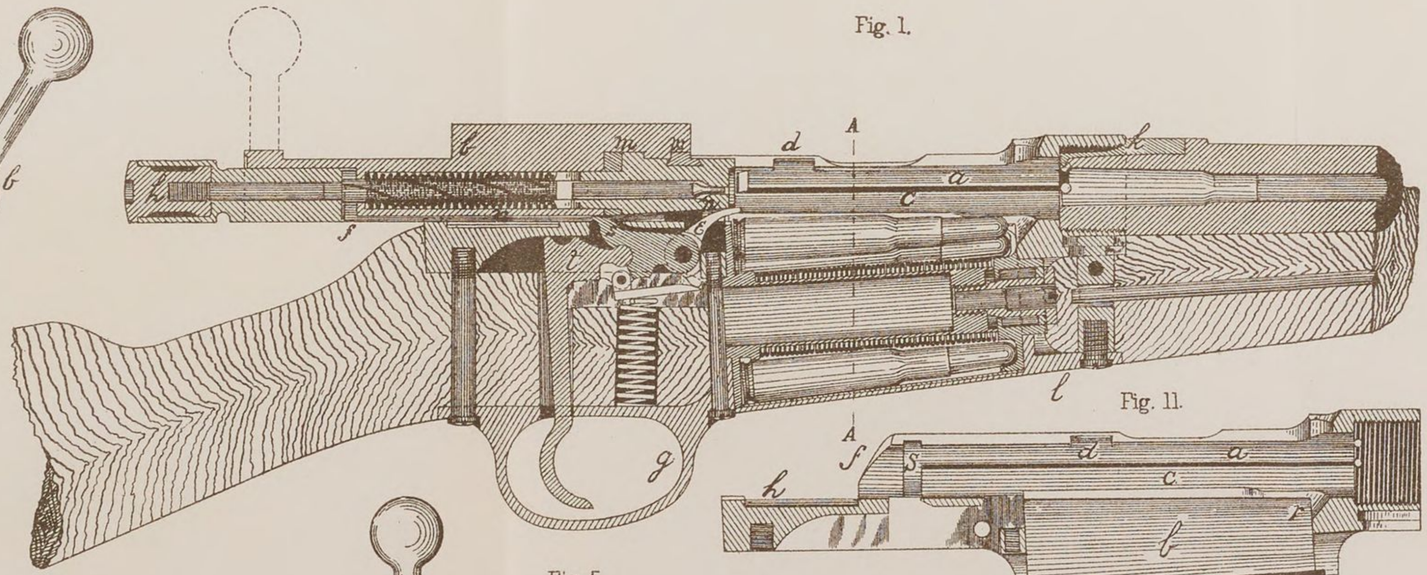


NO. 4.

DURST, No. 1.

PLATE IV.

Fig. 1.



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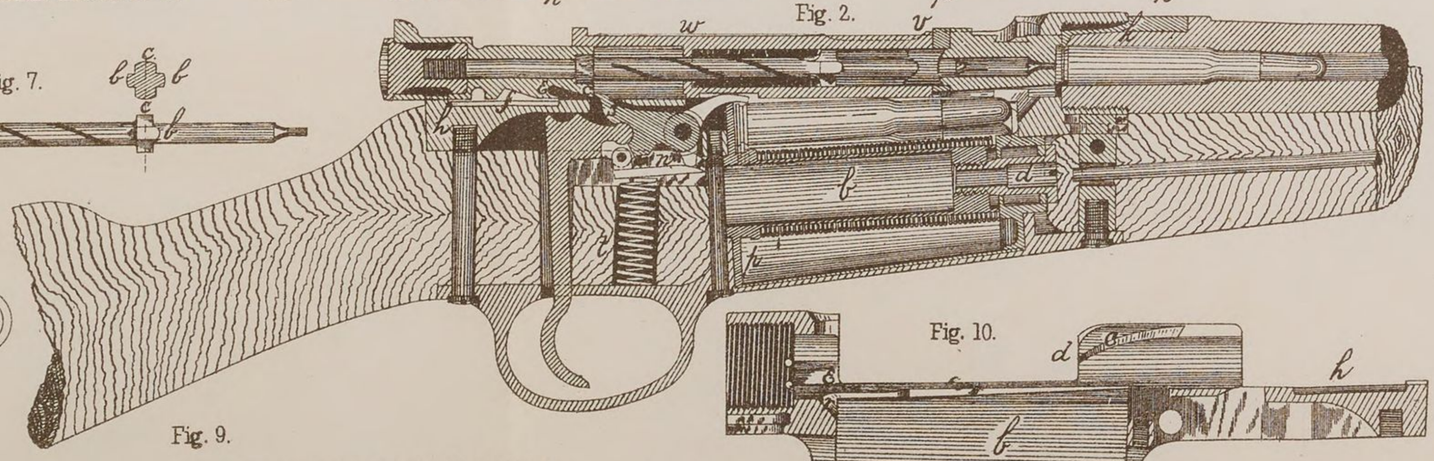

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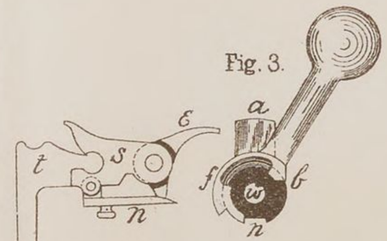

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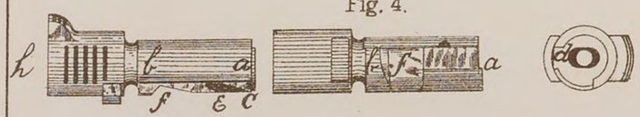

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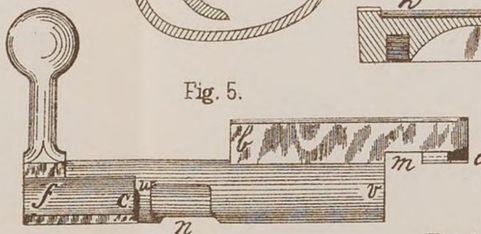


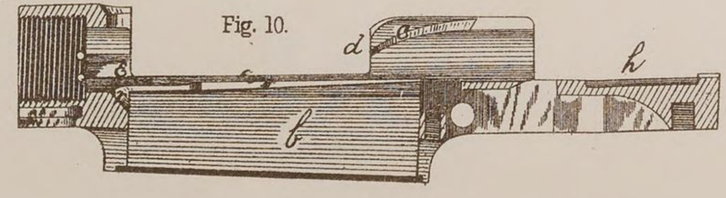
Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.



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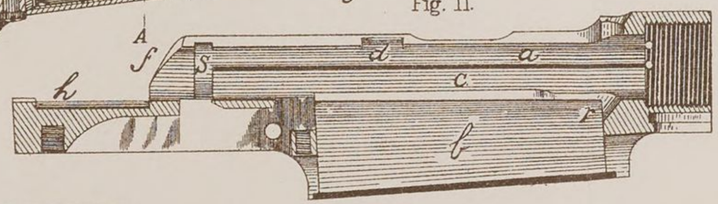
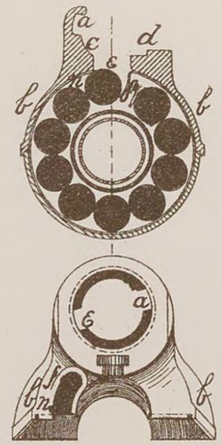


Fig. 12.

Fig. 13.



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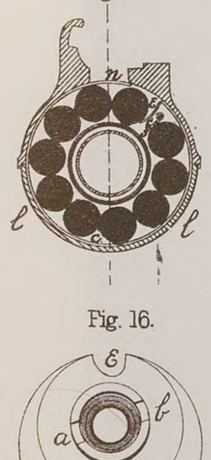
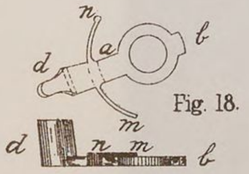


Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.



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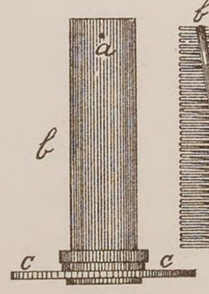

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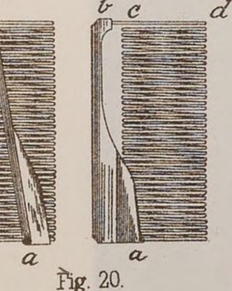


NO. 4.

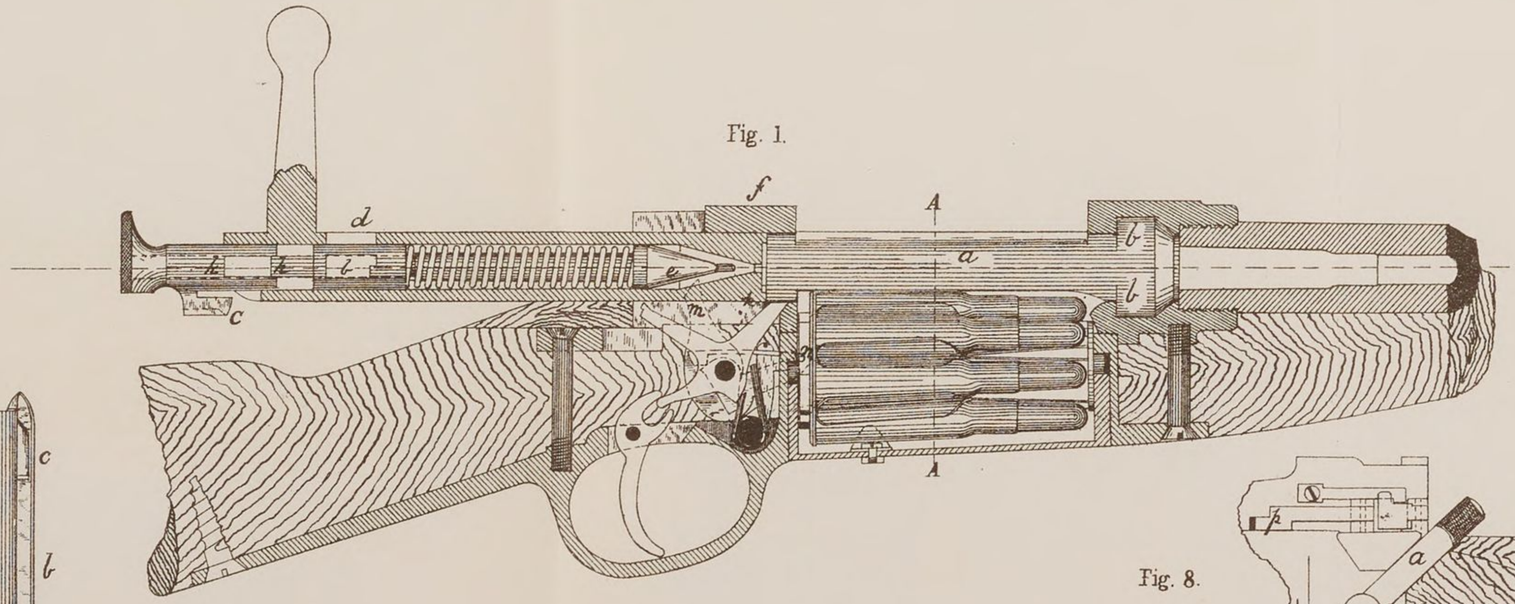
DURST. No. 1.

NO. 8.

BLAKE. No. 1.

PLATE V.

Fig. 1.



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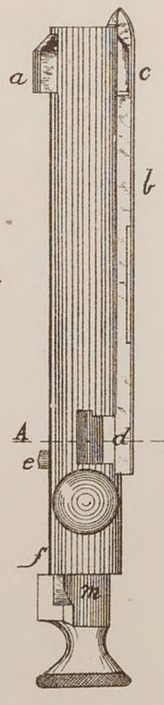

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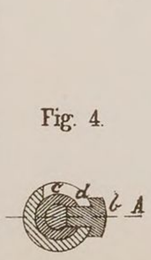

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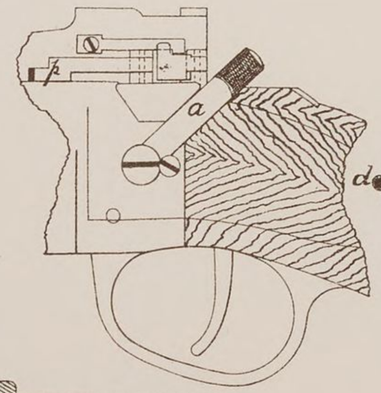

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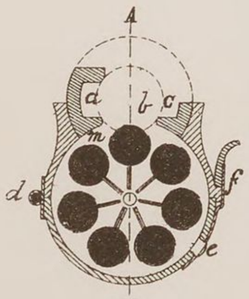

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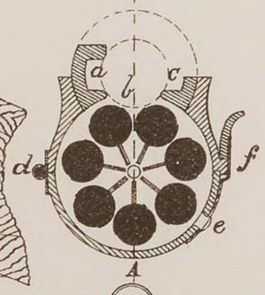
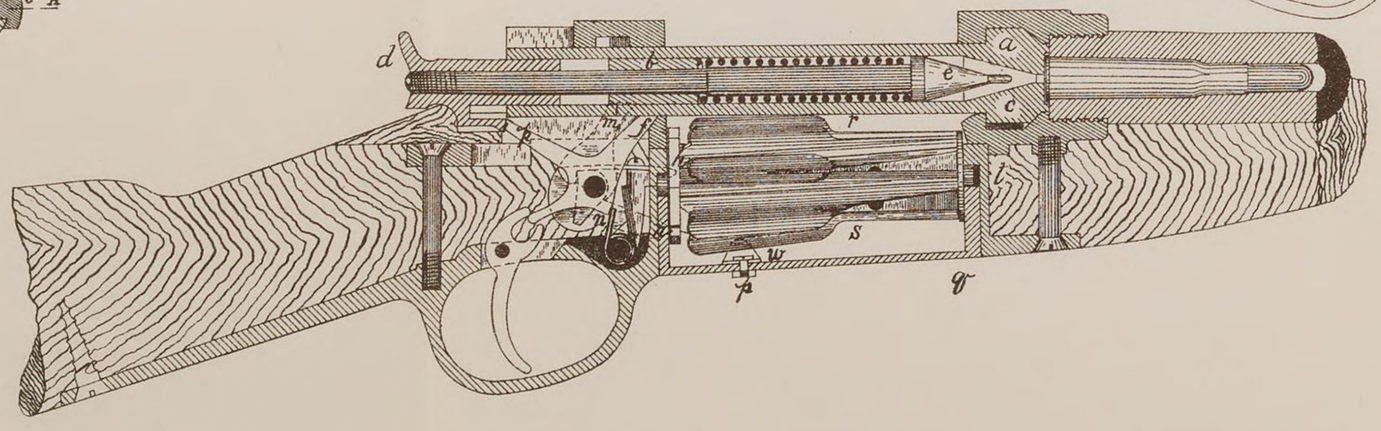


Fig. 7.

Fig. 2.

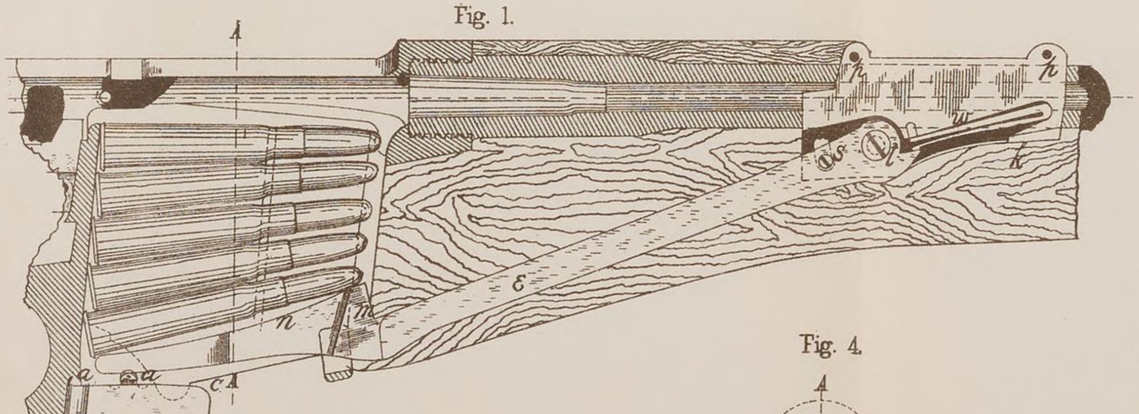


NO. 9.

RUSSELL-LIVERMORE.

No. 1.

Fig. 1.



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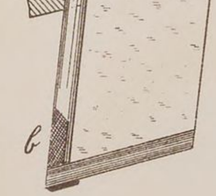
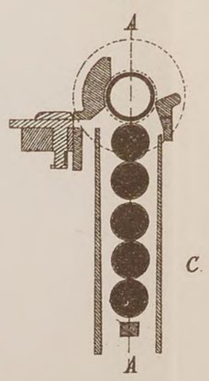


Fig. 4.



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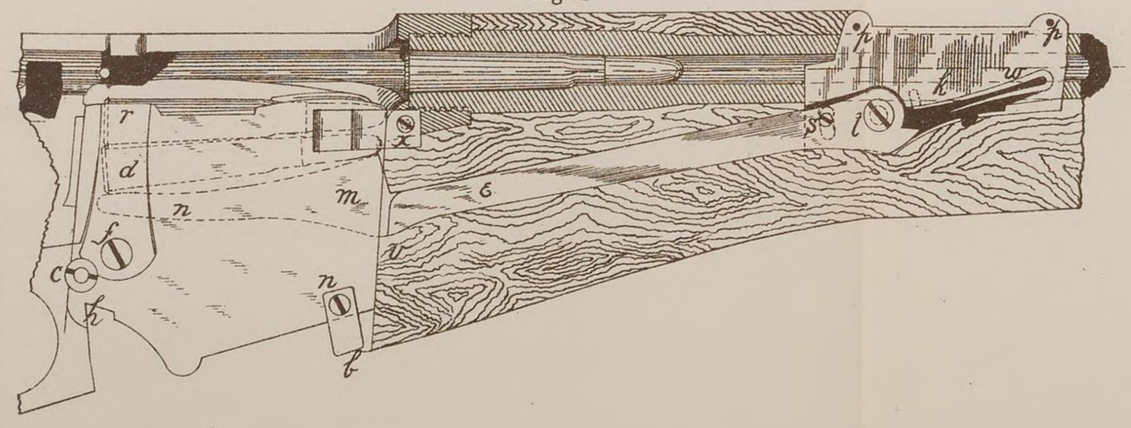


NO. 10.

RUSSELL-LIVERMORE.

No. 2.

PLATE VI.

Fig. 1.

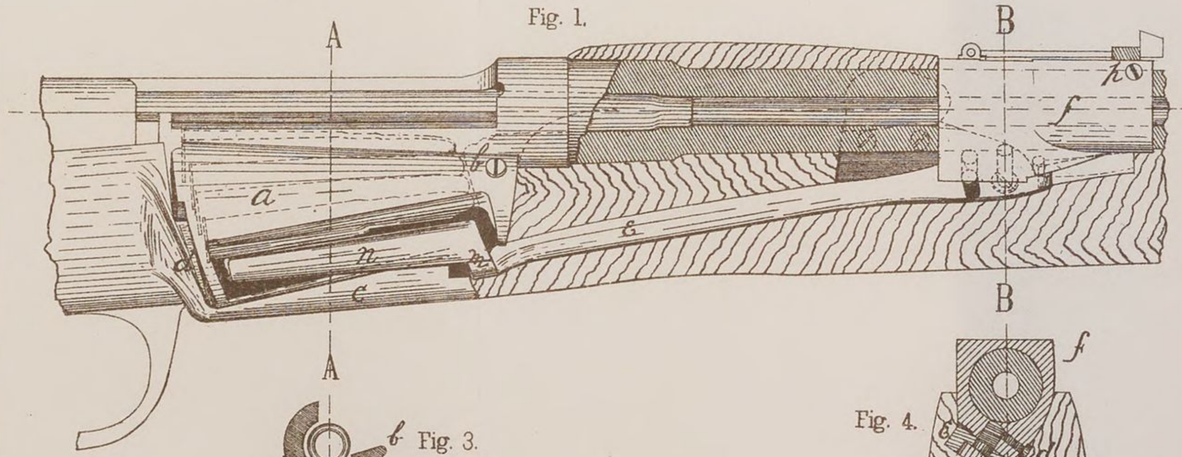


Fig. 3.

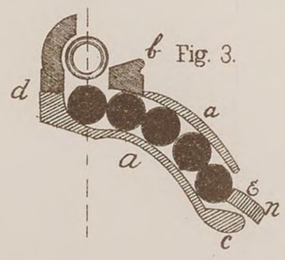


Fig. 4.

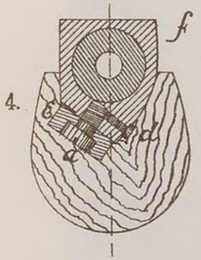


Fig. 2.

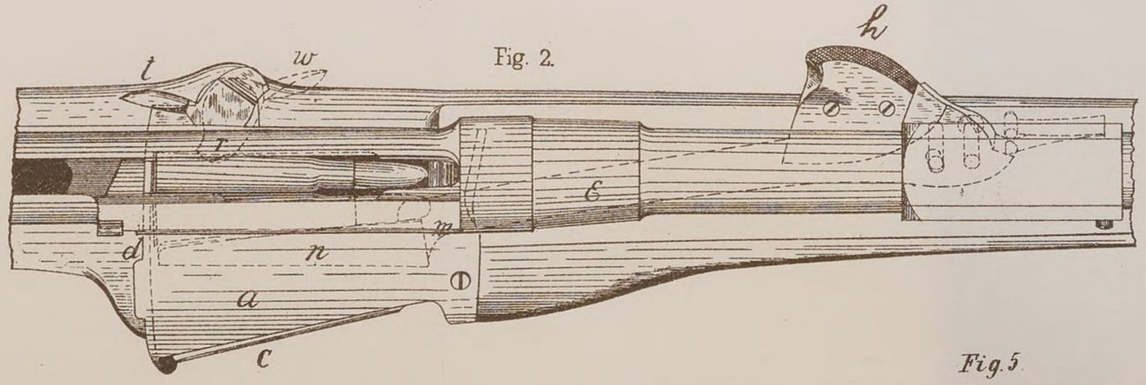
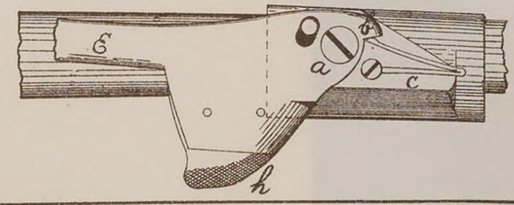
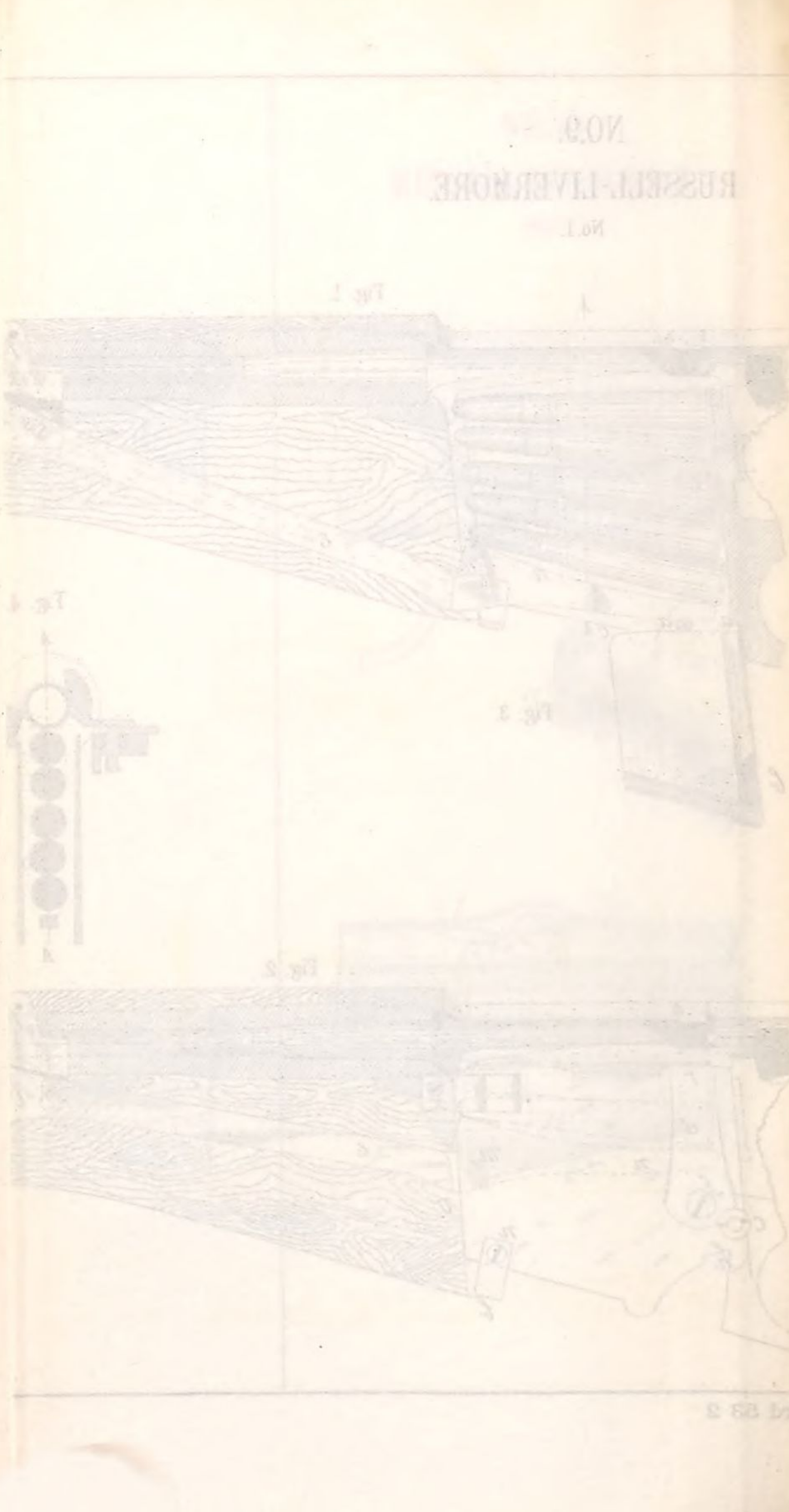


Fig. 5





NO. 12.

WHITE.

PLATE VII.

Fig. 1.

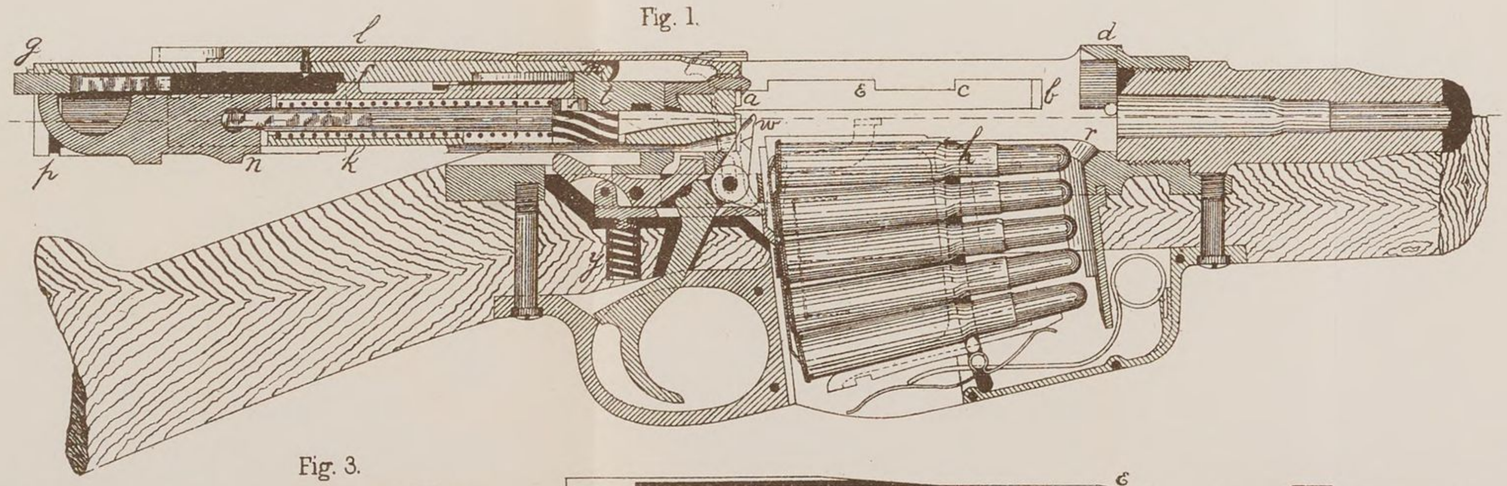
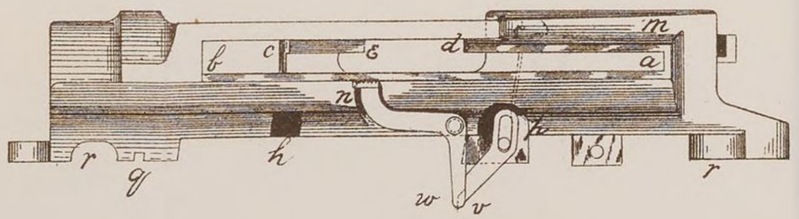


Fig. 16.

Fig. 4.



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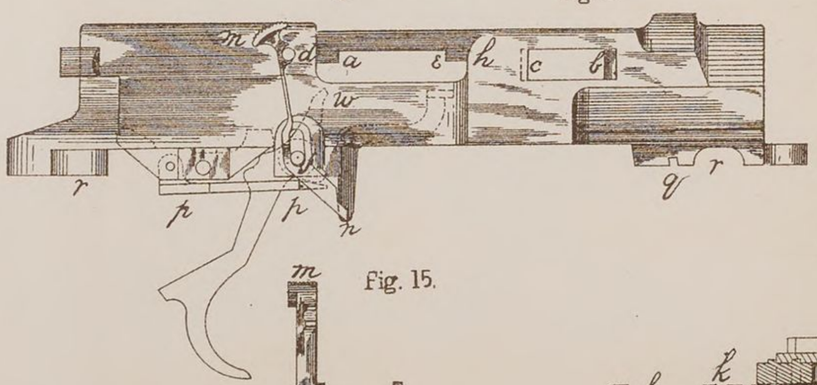

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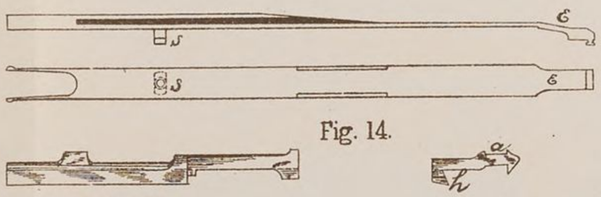

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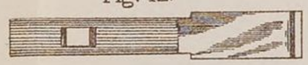


Fig. 13.

Fig. 15.

Fig. 2.

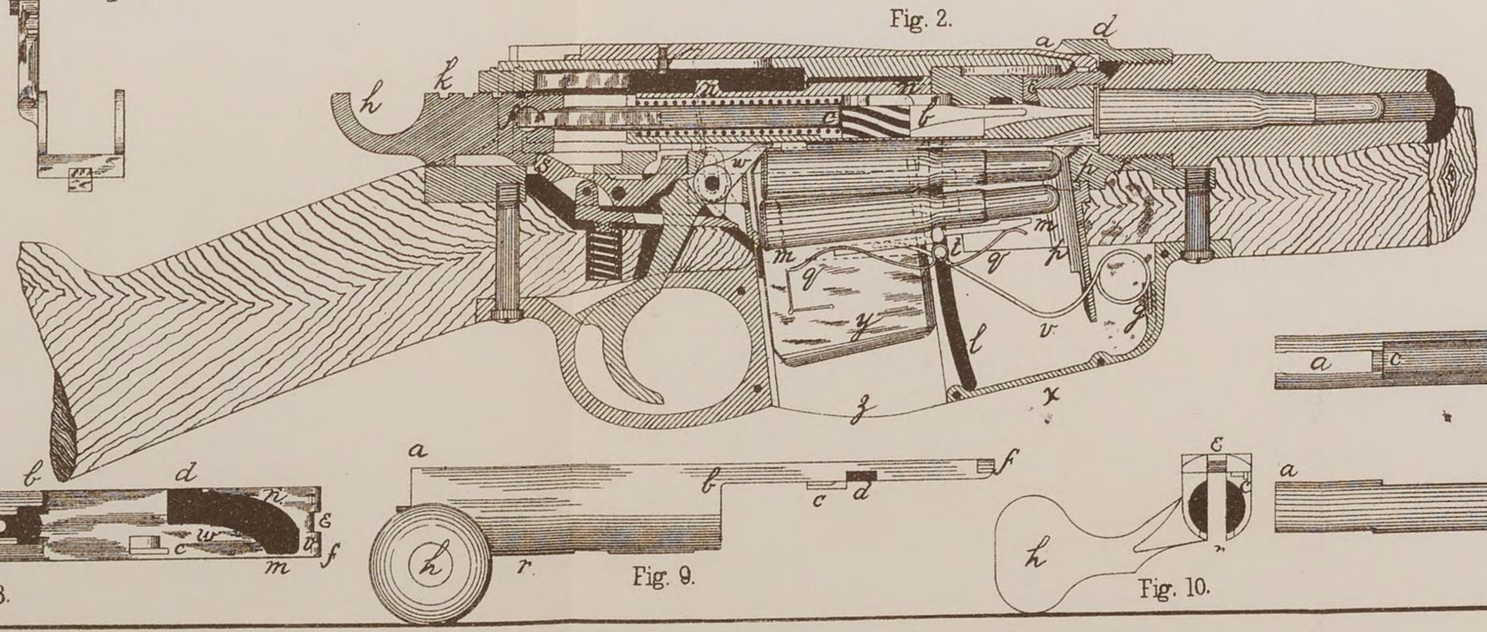
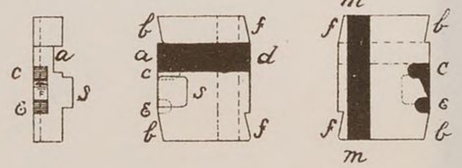


Fig. 11



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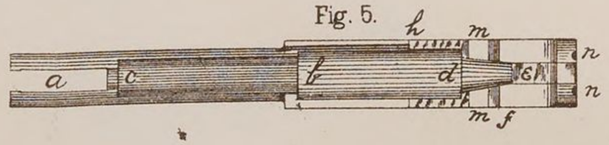

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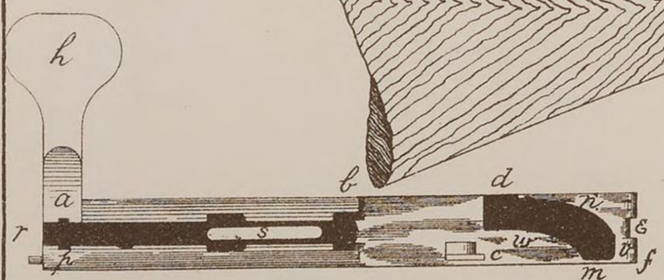
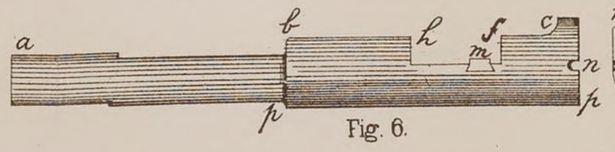


Fig. 9.

Fig. 10.

Fig. 6.



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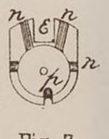
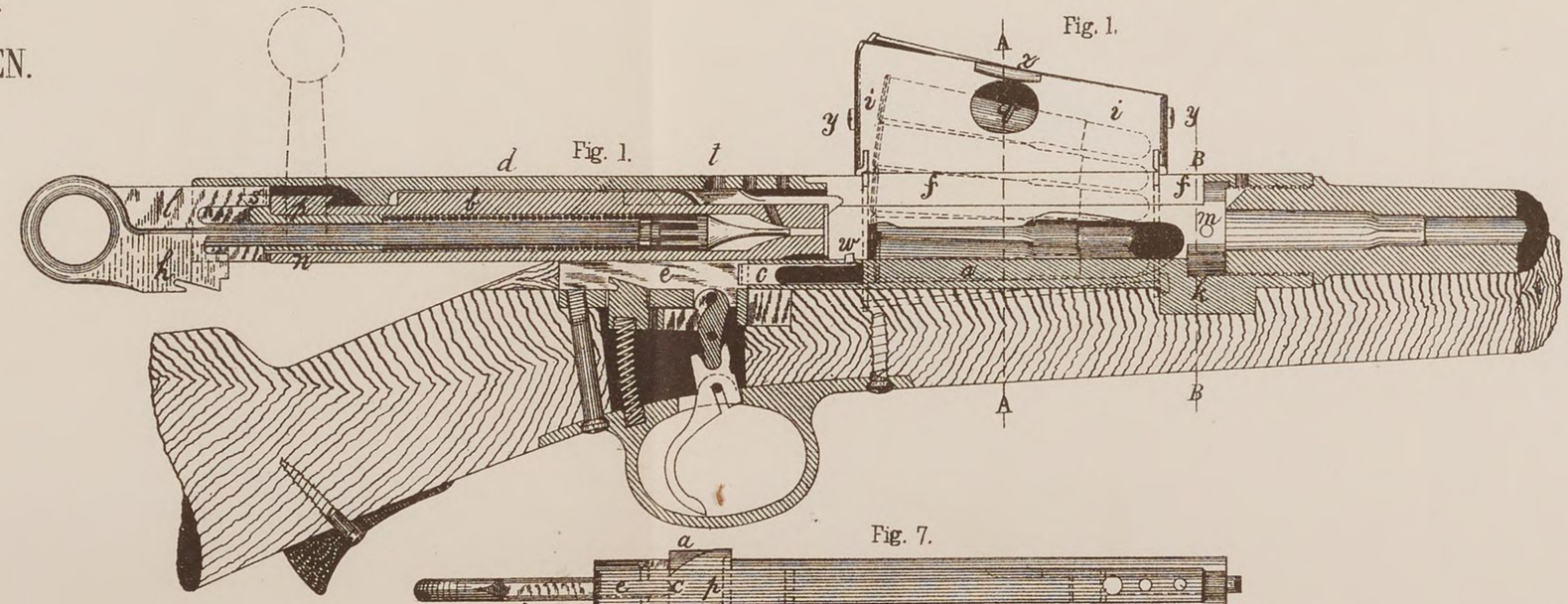


NO. 13.

HAMPDEN.

PLATE VIII.

Fig. 1.



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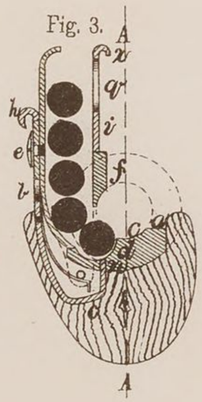

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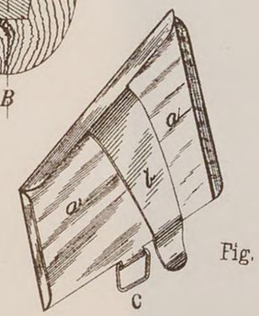
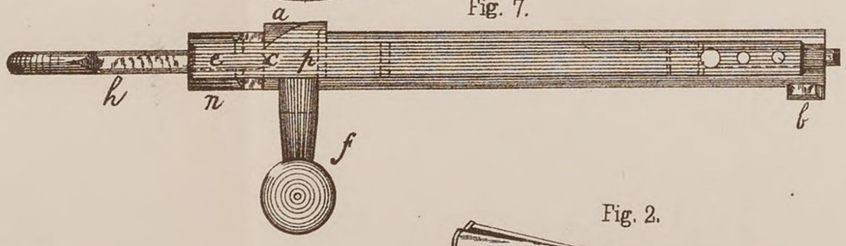


Fig. 10.

Fig. 7.



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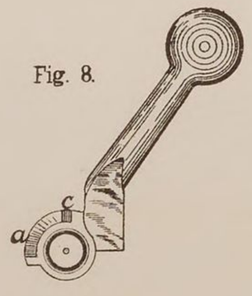


Fig. 2.

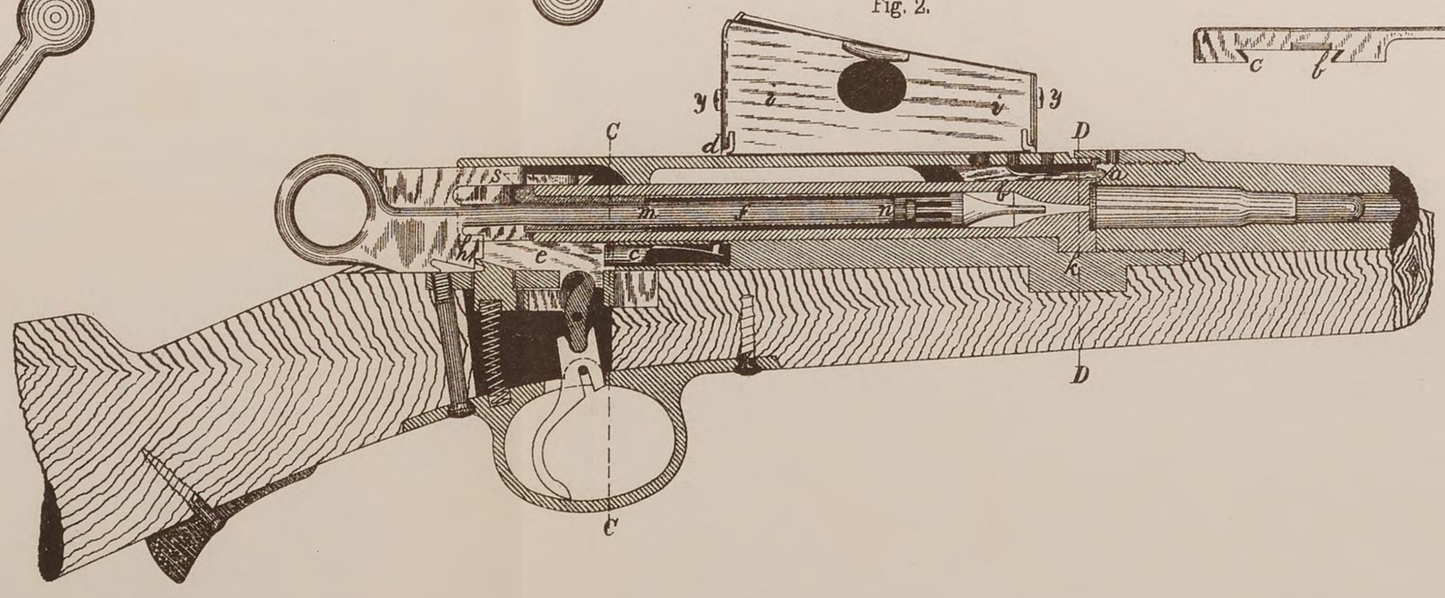
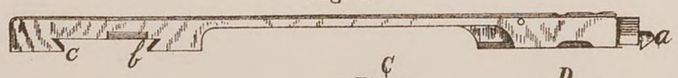


Fig. 9.



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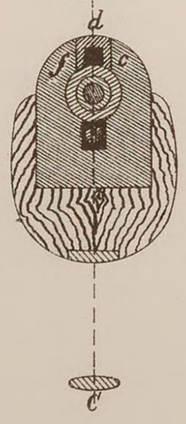

Fig. 6.

Ord 53 2

Appendix 9,'1893

APPENDIX 10.

REPORT OF BOARD OF OFFICERS ON CALIBER, RIFLING, SIGHTS, AND AMMUNITION FOR THE MAGAZINE RIFLE, MODEL 1892.

SPRINGFIELD ARMORY,
Springfield, Mass., September 30, 1892.

SIR: I have the honor to forward herewith report of the Board on Caliber, Rifling, and Sights for Magazine Arms, convened by Special Orders No. 223, Headquarters of the Army, Adjutant-General's Office, Washington, September 22, 1892.

The special report on sights and bayonets of foreign arms, forwarded to the board with your letter of the 16th instant, is returned herewith.

Respectfully, your obedient servant,

A. MORDECAI,
Colonel, Ord. Dept., U. S. Army, President of the Board.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Proceedings of a board convened pursuant to the following order:

SPECIAL ORDERS, No. 223.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, September 22, 1892.

[Extract.]

1. By direction of the Acting Secretary of War, a board of ordnance officers, to consist of—

Col. Alfred Mordecai,
Lieut. Col. Joseph P. Farley,
Capt. Stanhope E. Blunt,
Capt. Daniel M. Taylor, and
First Lieut. J. Walker Benét,

will convene at the Springfield Armory, Massachusetts, at 10 o'clock a. m. on Monday, September 26, 1892, or as soon thereafter as practicable, to arrange and recommend adoption of certain details of construction for the magazine rifle and carbine, model 1892.

The junior officer will act as recorder of the board.

The board will act under the instructions of and make its report to the Chief of Ordnance.

On the final adjournment of the board the members thereof will rejoin their prorer stations.

The travel enjoined is necessary for the public service.

* * * * * * *

By command of Maj. Gen. Schofield.

R. WILLIAMS,
Adjutant-General.

SPRINGFIELD ARMORY, MASS., *September 26, 1892.*

The board met pursuant to the foregoing order at 10:20 a. m.

Present, all the members.

The following letter of special instructions from the Chief of Ordnance, U. S. Army, was read to the board by the recorder:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, September 16, 1892.

GENTLEMEN: The system represented by the Krag-Jörgensen magazine rifle No. 5 has been selected by the Secretary of War for trial, with a view to adoption in the United States service. It will be designated as the "magazine rifle, model 1892."

You are instructed to make a study of and to recommend a suitable caliber for this gun, and suitable rifling, sights, and ammunition. The recommendation of the board is also required as to the use of the bayonet, and a special report on sights and bayonets is forwarded. The question of a ramrod, either for cleaning the gun or as a cleaning rod and bayonet combined, should be considered. If a rod is not considered desirable then some other cleaning apparatus should be devised. The board will further recommend what other appendages, if any, should be made for issue.

It is essential that this work should be taken in hand at once and that all diligence should be used in bringing it to early completion. The commanding officer of Springfield Armory has been instructed to afford the board every facility for carrying on its operations.

Having completed the report on the rifle, the board will then take up the subject of a carbine, constructed on the same system, and will make a similar report with reference to it.

Respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The BOARD ON CALIBER, RIFLING, AND SIGHTS OF MAGAZINE ARMS,
Springfield Armory.

The board then proceeded to consider the question of caliber.

After discussion, the following recommendation was adopted:

A caliber of 0.30-inch is recommended for the trial arm. This caliber is one well suited to a military arm, and especially adapted to the breech and magazine mechanism of the system selected for trial. To thoroughly consider all the questions governing the determination of caliber would require much time and an extended series of experiments, which the board does not consider advisable to institute in view of its instructions to reach a decision at an early date. The subject of ammunition was next considered as being most intimately connected with that of caliber. After discussion, the following recommendation was adopted:

Having decided upon the caliber of 0.30-inch, the board further recommends that the cartridge be the same in exterior form and dimensions as that used in the tests which resulted in the system represented by the Krag-Jörgensen rifle No. 5 being selected for trial; that the bullet be of lead alloyed with tin or antimony, having a jacket of German silver or nickeled steel and without lubricant or cannelures; that the weight of the bullet be 220 grains; that the charge be 36 to 40 grains of smokeless powder, or such lesser weight as will give the above bullet a muzzle velocity of about 2,000 feet per second with a chamber pressure not exceeding 45,000 pounds per square inch. With the cartridge recommended, in the opinion of the board, no provisions should be made for reloading by troops.

The subject of a suitable rifling was then discussed, and the board, at 5:40 p. m., adjourned to meet at 10 a. m. Tuesday, the 27th instant.

SPRINGFIELD ARMORY, MASS., *September 27, 1892.*

The board met pursuant to adjournment at 10 a. m.

Present, all the members.

It was decided to postpone the consideration of the question of a suitable rifling and to take up the subjects of sights and the bayonet. After discussion, the following recommendations were adopted:

The board is of opinion that a sight for a military arm should be suited

for use in war, and that with the flat trajectory which the trial arm gives there is no necessity for graduations for differences in range of less than 100 yards; that a drift or wind gauge is not necessary for war purposes, and that as in time of war the arm will be of necessity subjected to very hard usage the sight should be of as simple and strong construction as possible.

The board recommends a rear sight of the same general pattern as that used on the Krag-Jörgensen magazine rifle No. 5, with certain modifications taken from the German infantry rifle. The main features of the sight are as follows: A fixed base graduated by steps from 300 to 600 yards; a leaf, capable of being turned down, either forward or backward, graduated to about 2,200 yards, and provided with notches on the side at every 100-yard graduation for receiving the catch of the slide. The face to be bright and to carry blackened graduation numbers, as in the German sight. The front sight recommended is similar to that of the experimental .30-caliber Springfield rifle of most recent pattern. A front-sight cover is not considered necessary. The board is of opinion that a knife bayonet of the general design used in all European services is superior to either a triangular or a ramrod bayonet, and should form a part of a modern small arm. It, therefore, recommends for use with the trial arm a knife bayonet similar to that on the Swiss magazine rifle, and provided with a metal scabbard; the attachment to the knife bayonet to be below the barrel at the upper band, which shall also carry the stacking swivel. It is recommended that two gun-sling swivels be provided, one of which shall be attached to the lower band, and the other to the butt of the stock, 30 inches below the lower band.

The subject of the ramrod and other appendages was next considered.

After discussion, the following recommendation was adopted:

A steel ramrod with a brass head, to be carried on the arm, is recommended. In the opinion of the board, no other appendage should be carried on the gun, but each noncommissioned officer should be provided with a headless shell extractor and screw-driver.

It is recommended that the face for the butt plate be straight, and that the butt plate be provided with a short tang for a screw.

The board then, at 5:15 p. m., adjourned to meet Wednesday, the 28th instant, at 10 a. m.

SPRINGFIELD ARMORY, MASS., *September 28, 1892.*

The board met pursuant to adjournment at 10 a. m.

Present, all the members.

The subject of the carbine was then taken up, and, after discussion, the following recommendation was adopted:

It is recommended that the carbine be of the same caliber as the rifle and adapted to the same cartridge; the barrel to have the same rifling and to be 22 inches long, its dimensions up to that distance from the chamber being the same as those of the rifle barrel; the sights to be of the same general design as those for the rifle, the rear-sight base being, as for the rifle, graduated by steps from 300 to 600 yards; that the stock extend to within 3 inches from the muzzle and be similar to that for the rifle, that a sight-protector band be placed in front of the rear sight; that the upper band be similar to that for the rifle, omitting the attachment for the bayonet and the stacking swivel; that

the butt plate be the same as that of the rifle; that a short swivel bar and ring be attached to the left side of the stock about 5 inches from the butt plate; that the carbine be provided with a ramrod, as on the rifle, but that no other appendage be carried on the arm; that a headless shell extractor and screw-driver be carried by noncommissioned officers.

The subject of a suitable rifling was then resumed, but no conclusion was reached, and the board at 5:30 p. m. adjourned to meet Thursday, the 29th instant, at 10 a. m.

SPRINGFIELD ARMORY, MASS., *September 29, 1892.*

The board met pursuant to adjournment at 10 a. m.

Present, all the members.

The subject of a suitable rifling was resumed, and the following recommendation was adopted:

In view of the desirability of completing a trial arm at an early day, and of the delay necessarily incident to extended tests with different systems of rifling, the board recommends that for the present the following system of rifling be used in the magazine arms to be manufactured: four plain grooves three times the width of the lands and 0.004 inch deep, the twist being one turn in 10 inches, and that the length of barrel be 30 inches.

The board further recommends that a thorough test of the different systems of rifling used in some of the European services be made for the purpose of determining the best rifling for ultimate adoption.

Having completed the business before it, the board then, at 1 p.m., adjourned *sine die*.

A. MORDECAI,
Colonel, Ordnance Dept., U. S. Army.
J. P. FARLEY,
Lieutenant-Colonel, Ord. Dept., U. S. Army.
S. E. BLUNT,
Captain, Ordnance Dept., U. S. Army.
D. M. TAYLOR,
Captain, Ordnance Dept., U. S. Army.

J. W. BENÉT,
First Lieutenant, Ord. Dept., U. S. Army.

(5139–'92.)

APPENDIX 11.

REPORT OF PRINCIPAL OPERATIONS OF THE SPRINGFIELD ARMORY, MASSACHUSETTS, WITH SPECIFICATIONS FOR STEAM-POWER PLANT, BY COL. ALFRED MORDECAI, COMMANDING.

SPRINGFIELD ARMORY,
Springfield, Mass., August 28, 1893.

SIR: I have the honor to submit the following report of the principal operations at this armory during the fiscal year ending June 30, 1893:

NEW SHOPS.

When the undersigned assumed command of the armory, February, 1892, the new milling shop, as previously reported, had been completed and occupied; the new building for carpenter and stocking shops had been completed and the main lines of shafting, one on each floor, erected, and the building was ready for the installation of the machinery, so soon as power might be available, to be drawn from new engines to be erected in the new building for machine and filing shops.

This last building, running in a general north and south line, connects the other two. It was commenced in April, 1891, and by February, 1892, the exterior was completed, the brick arches in place, and floor linings laid on the first and second floors.

Upon reporting for duty, the new commanding officer found that advertisement had been issued for the engines, boilers, and shafting required to equip this building.

The specifications had been drawn for two Wheelock engines and materials for four boilers, to be constructed upon a design of Mr. C. C. Weber, of Springfield, Mass.

A new advertisement was issued for engines and boilers to fill general conditions, permitting of a wide range of designs and consequently of competition amongst manufacturers. A copy of the advertisement, instructions, and specifications is appended hereto, marked A.

When the proposals for the steam plant were opened on June 2, 1892, there were bids for six different engines, and sixteen bids for boilers, covering six distinctly different designs. After a full consideration of all the designs and specifications presented, the acceptance of the bid of the Philadelphia Engineering Works for their Corliss engines and for Babcock and Wilcox boilers was recommended and approved by you.

The contract, as originally drawn, required the entire plant to be completed by December 22, 1892. An unusually severe winter and other

causes rendered necessary the extension of the contract, finally, to May 22, 1893. Though the work of erecting the plant was supposed to be completed by the above date, numerous points shown during the test of the engines to require correction have delayed the final acceptance of the plant.

During the year the interior of the new machine and filing shops has been completed; the basement floor and the upper floor on first and second stories have been laid; work benches have been put in and partitions erected, forming rooms for the different purposes necessary to the shops.

This main building, running north and south, is divided on each floor by brick partition walls into a middle and two end sections. On the second floor the north section is being fitted up with machinery as an extension to the milling department. The filing department occupies the remainder of this floor. The north end of the middle section has one room cut off for plating room and one for an inspection room. In the north end of the south section is the browning room, and next an inspection room. On the second floor of the L, at the south end of the building, the polishing room is being fitted up, and adjacent to this is a room for repair, etc., of emery wheels.

On the first floor will be the machine shop, occupying the north and middle sections, with a tool room in the former and the foreman's office in the latter. The south section of this floor will be devoted to the assembling of arms and the manufacture of appendages and bayonet scabbards, as far as done in the machine shop. On the first floor of the L, beneath the polishing room, has been fitted up the drafting room, the printing room, and the master armorer's office.

In the basement will be the tinner, the pipe fitter, and the millwright, each with his necessary machines; also storage for new chests awaiting arms, and space for other purposes.

No provision having been made in the new building for accomplishing the test to which each arm is subjected by firing, with your approval, the erection has been commenced of a small building extending out from the south end of the middle section; in this, in the basement will be the testing room, and the first and second floors will be fitted up as water-closets directly accessible from the shops by a short passageway.

The winter of 1892 and 1893 showed that the want of gutters to the new buildings, especially over the doorways, was most injurious to the structures and extremely inconvenient. Ice formed along the eaves and icicles of much weight hung in many places, making the entrances very dangerous. A design for a covered protection of brick with tin roof for each entrance, to shield the steps and serve as storm door, was submitted, and having been approved by you the construction is about to be commenced.

That materials may be carried readily to the elevators in the milling shop and in the carpenter and stocking shops doors have, with your approval, been cut in the basements immediately opposite the elevators, and driveways are being constructed down which teams can be backed.

A low structure of timber, 90 by 40 feet, containing 12 bins for coal, is about to be constructed, 60 feet to the rear of the shops, and between the boiler room and the hardening and tempering room, the latter being in an L at the north end of the main building. From these bins tracks for cars will be laid to the boilers and furnaces.

The erection of the main lines of shafting was completed January 1 last.

The four boilers which have been put in are designed, one for power, one for heating shops, one for heating office, quarters, and other buildings, and one for reserve.

One engine at a time will supply all the power ordinarily required.

All the work of the stocking shop will be done on the second floor of the building erected for that purpose, and on the first floor of the same building will be all that pertains to the carpenter shop, except a Daniels' planer, which will be in the basement. These shops are being fitted up and the machinery installed, and it is expected that by October they will be in operation for the work relating to them, the only delay being the successful completion and acceptance of the power plant.

MAIN ARSENAL.

The window frames and sashes of all the floors of the main arsenal have been painted with two coats; also the wall below the water table and the snow guard and cornice.

MASTER ARMORER'S QUARTERS.

A set of quarters, formerly occupied by officers, had last year been moved eastward 138 feet, along the line toward the shops. It had been raised and established upon a new foundation and cellar, and was being fitted up as residence for the master armorer. For want of funds work upon it was suspended in April, 1892. After July 1 work was resumed. An addition, 10 feet deep and two stories high, was built at the rear for storeroom, coal room, and pantry. The first floor was fitted up with ash, and the entire house painted within and without. It was completed last December and occupied immediately thereafter.

NEW QUARTERS FOR OFFICERS.

In 1891 Congress appropriated $20,000 for two sets of officers' quarters.

For these buildings plans were drawn somewhat similar to the quarters for officers recently erected at Watervliet Arsenal.

The recommendation, which had been approved by the Chief of Ordnance, was to erect one house upon the site of that lately occupied by the master armorer, and the second at a point midway between that and the new house of the master armorer. Work could not be commenced till the completion of the last-named house, and therefore at the beginning of this year no positive steps toward the erection of the new quarters had been taken.

In November last you authorized the employment of an architect to revise the old plans or draw up new ones. The results were the plans and specifications which were approved by you March 17, 1893. Copies of these were sent to your office July 8, 1893, for publication.

The house formerly occupied by the master armorer has been torn down and the site made ready for the new building.

On March 29, 1893, advertisement was issued for proposals for building the new quarters. On account of labor troubles in Springfield but two bids were received, both so unreasonable that they were rejected, and further action was postponed till some settlement of the labor troubles might be reached.

MANUFACTURE OF ARMS.

On September 19, last, instructions were received from you to make preparations for the manufacture of the magazine rifle, caliber .30, recommended by the Board on Magazine Arms, to be known as the "Magazine rifle, model 1892."

The arm that had been before the board was sent to the armory to be used as the model rifle.

The first step taken was to have made for each piece a wooden pattern of the forging, which it was thought would be required, from which the piece could be formed. The master armorer then made a study of each piece, and drew up a scheme of the operations and the order in which they should be taken to construct each piece. These schemes were next placed in the hands of mechanical draftsmen, by whom were worked up designs for the fixtures required by the machine in which each operation would be performed.

In order to expedite the work, and to make use of machinists of different grades, the general drawings of fixtures were dissected by draftsmen of a lower grade and drawings made of the parts in detail.

Every effort has from time to time been made to push the work forward. Competent workmen, as fast as found, have been employed, new machines for general work purchased, and all old machines on hand which had been laid aside have been repaired and set up for use in the machine shop; screws and tools which had heretofore been made at the armory have been procured from manufacturers elsewhere.

When a fixture is completed the work for it is by no means over; the cutters and guides for use with it have to be made, and then all fitted to its machine, adjusted, and tested to determine whether or not the work required can be properly accomplished.

In working out the pieces for the arm it has been found necessary to modify the schemes as first drawn; the order of some operations has been changed and additional operations have in many cases been interpolated.

Drawings have been made of the first and second floors of the milling shop, and on these each machine has been located in position; the master armorer has assigned to each machine and marked on the plan the fixture or fixtures to be used on each; the location of the machines has been changed, where necessary, to place the operations in their proper order, as nearly as practicable.

All this has consumed much time and labor. and it will probably be October before the manufacture of the new rifle can actually be commenced. Up to June 30 there had been expended on tools and fixtures for labor alone $43,659.25.

On the last day of the fiscal year the progress of the work on "fixtures" was as set forth in the following table:

Magazine rifle, model 1892—Condition of work on fixtures June 30, 1893.

Part.	Fixtures required.	Fixtures completed.	Fixtures in progress.	Drawings made for other fixtures.
Bolt	28	28	.....	.....
Extractor	14	13	1	.....
Extractor spring	5	.....	.....	5
Firing pin	3	.....	.....	.....
Striker	8	7	.....	1
Mainspring	1	.....	.....	.....
Cocking piece	12	10	.....	2
Sleeve	24	22	2	.....
Securing stud	3	.....	.....	.....
Safety lock	7	7	.....	.....
Gate	19	18	1	.....
Carrier	22	6	10	6
Follower	12	.....	.....	12
Magazine spring	6	.....	.....	6
Hinge bar	1	.....	.....	.....
Hinge-bar head	10	10	.....	.....
Side plate	14	14	.....	.....
Cut-off	8	.....	.....	.....
Cut-off spring	6	3	.....	3
Ejector	11	11	.....	.....
Receiver	128	105	16	7
Guide lip	7	.....	.....	.....
Sear	8	8	.....	.....
Sear spring	1	.....	.....	.....
Trigger	9	9	.....	.....
Guard	11	11	.....	.....
Butt plate	5	.....	.....	.....
Upper band	12	3	7	2
Stacking swivel	4	.....	.....	.....
Lower band	6	.....	.....	4
Lower-band swivel	3	.....	.....	3
Swivel plate	7	.....	.....	7
Front sight	6	.....	.....	.....
Bayonet blade	12	.....	.....	12
Bayonet pommel	8	.....	5	3
Bayonet guard	9	2	3	4
Bayonet catch	5	.....	.....	.....
Bayonet-catch nut	1	.....	.....	.....
Hand-guard springs, rear	2	.....	.....	.....
Rear-sight base	20	.....	.....	.....
leaf	17	.....	.....	.....
slide	13	.....	.....	.....
slide cap	13	.....	.....	.....
slide catch	8	.....	.....	.....
base spring	6	.....	.....	.....
joint pin	2	.....	.....	.....

Besides the number of fixtures given above it is known that others, though not exactly how many, will be needed.

The table shows that for 47 of the parts of the new rifle there will be required, so far as determined on June 30, 537 fixtures, and of this number, at that date, 287 were completed and 45 more were in the hands of the workmen.

On June 30 118 pairs of dies had been made for forging parts of the new arm and 325 mills had been completed. Of machines for use in the manufacture of the stock 3 had been altered and 9 were in hand.

In addition to the fixtures and tools required, a large number of gauges are needed to verify the correctness of the work. These will amount to two to nearly each fixture.

The total number of parts in the magazine rifle and bayonet is 88 and in the Springfield rod-bayonet rifle 84.

In the manufacture of the latter arm, omitting the stock, there were employed 449 fixtures and 1,097 gauges.

It having been decided that the manufacture of rifles, caliber .45, should be brought to a close during the month of June, the forging of parts of that arm was stopped in February last, and from then on only

such pieces were forged or completed as were needed for the arms to be made, or for repair hereafter of arms in service. Workmen were laid off from day to day, as their services were no longer needed.

Notwithstanding this course there now remain on hand many forgings and parts in different stages of manufacture, nearly all of which will, doubtless, ultimately be relegated to the scrap heap.

ARMS UNDER CONTRACT.

The Department, on June 16, 1892, entered into contract with the Colt's Patent Fire-arms Manufacturing Company to supply 5,000 Colt's double-action revolvers, caliber .38, army model 1892.

The adoption of this revolver was the result of trials made in the service and of tests at this armory, and the arm as perfected was deemed to embrace the fewest number of objectionable features of any pattern that was known.

The inspection of these revolvers was made by employés of this armory, under the direction of Capt. D. M. Taylor, Ordnance Department, by whom each was inspected after completion.

The whole number of pistols, with appendages and spare parts, were delivered before the expiration of the contract, July 31, 1893.

STEEL FOR GUN BARRELS.

On June 10, 1892, complying with your instructions of March 15, 1892, a report was submitted from this office on the manufacture of gun barrels at this armory since the adoption of steel for the purpose. At the same time reference was made to tests that were then being continued of samples of steel for barrels, caliber .30.

You directed that the investigations of the physical qualities of steel for gun barrels should be continued, and that experimental barrels should be prepared and subjected to endurance tests, to the end that a proper quality of steel for a .30-caliber barrel might be determined upon at the earliest practicable date.

Manufacturers of steel were invited to submit samples for test, to conform to the following requirements, viz:

Tenacity, about 100,000 pounds; elastic limit, not less than 60,000 pounds; elongation, 15 to 20 per cent; to be homogeneous, free from seams and hard spots, and to be capable of being worked readily by the tools used for the purpose at this armory. The elastic limit had in 1891 been placed at 70,000 pounds, and in September, 1892, had been raised to 80,000 pounds, to encourage experiments with nickel steel. As it appeared later impracticable to obtain a steel with the latter limit of elasticity that could be worked the standard was reduced to 60,000 pounds.

A number of samples, as shown by the subjoined table, was received whose physical properties approached the standard, but when the most favorable ones were tested in barrels they were found to contain hard spots or seams, which arrested or diverted the drill and produced a crooked bore. Up to the present no steel has been found which possesses the desired physical properties and can at the same time be worked without unreasonable loss by the machines in use at the armory.

Specimens tested to deter mine a steel suitable for rifle barrels, caliber .30.

No.	Date.	From whom.	Designation.	Tenacity.	Elastic limit.	Elongation.	Remarks.
	1892.			*Pounds.*	*Pounds.*	*Per cent.*	
1	Mar. 2	Atha & Illingworth	Sample A	71,440	56,000	26	Properties too low.
2	Mar. 2	....do	Sample R. I.	113,280	72,000	15	Duplicate samples not satisfactory.
3	Mar. 2	....do	Sample R. I. 2	87,360	64,000	23	
4	Mar. 23	....do	Stock for caliber .45	62,040	42,000	31	Properties too low.
5	Mar. 23	....do	....do	65,280	43,000	30	
6	Apr. 5	....do	Stock for caliber .30	85,120	45,000	26	
7	Apr. 5	....do	....do	84,000	45,000	24	Barrels made and tested; properties too low.
8	June 24	Spaulding & Jennings	No. 6, special	111,640	79,000	15	
9	June 24	....do	....do	113,200	79,000	13	Barrel made and tested; metal not uniform.
10	June 28	....do	No. 7, nickel 3 per cent	112,160	86,000	15	
11	June 28	....do	....do	114,960	85,000	18	Barrel made and tested; metal could not be duplicated.
12	Aug. 8	Atha & Illingworth	Nickel, proportion not known	79,800	56,000	27	
13	Aug. 8	....do	....do	80,000	59,000	26	Barrel made and tested; properties too low.
14	Aug. 8	Park Bros	Sample	63,920	45,000	32	
15	Aug. 8	....do	....do	63,920	44,000	32	Properties too low.
16	Oct. 24	....do	....do	91,880	55,000	19	Metal too hard to drill.
17	Nov. 25	Atha & Illingworth	....do	100,720	67,000	19	Satisfactory, but stock not homogeneous.
18	Nov. 25	Bethlehem Iron Co	Nickel, 25 per cent	130,840	84,000	25	
19	Nov. 25	U. S. Navy	....do	111,680	68,000	37	Barrels made, turned, and drilled only with greatest difficulty.
	1893.						
20	Feb. 25	Park Bros	Stock, for caliber .45	71,200	45,000	29	
21	Feb. 25	....do	....do	68,400	47,000	31	Barrels made, worked well; properties too low.
22	Feb. 25	Atha & Illingworth	Sample, select	112,400	68,000	17	Barrel made; metal not homogeneous.
23	Feb. 28	Midvale Steel Co	Sample, 1909	141,040	63,000	10	
24	Feb. 28	....do	Sample, 8068	128,440	69,000	15	
25	Feb. 28	....do	Sample, 8622	119,240	73,000	2	Barrels made, all too hard to be turned and bored by machines used; not homogeneous.
26	Apr. 18	Atha & Illingworth	New sample of No. 22	99,640	60,000	19	Barrels made; worked well.
27	Apr. 18	Spaulding & Jennings	Stock No. 7, nickel	91,440	56,000	23	Barrel worked well; properties too low.
28	May 9	Windsor Locks Co	Sample	100,480	60,000	20	
29	May 9	....do	....do	92,080	55,000	24	Company would not agree to furnish homogeneous metal.
30	June 14	Spaulding & Jennings	Sample, under bid	95,600	60,000	21	
31	June 14	....do	....do	95,800	59,000	20	Three barrels made; turned well; two in drilling developed seams.
32	July 12	Park Bros	....do	103,840	47,000	$16\frac{6}{10}$	Two barrels made; turned hard in drilling; hard spot and seams.
33	July 12	Howe, Brown & Co	....do	70,720	41,000	28	Two barrels made; turned very well; did not drill well.
34	July 12	Spaulding & Jennings	Nickel, No. 27, "treated"	91,000	68,000	25	Barrels made; the result of "treatment" not uniform.
35	July 20	Atha & Illingworth	Stock, like No. 26	110,080	65,000	$13\frac{6}{10}$	
36	July 20	....do	....do	96,000	61,000	$22\frac{1}{3}$	Barrels made; drilled badly and bore rough.
37	Aug. 12	Spaulding & Jennings	Sample, under bid	97,520	61,000	23	Barrels made; hard spots found in drilling.
38	Aug. 12	Midvale Steel Co	....do	104,880	57,000	$16\frac{6}{10}$	Seven barrels made, two of which drilled crooked.

Careful trials are now being conducted to determine whether the inaccuracy in drilling can possibly be due to the treatment of the metal in the manufacture of the barrel or to inaccuracies in the working of any of the machines.

Gun barrels, caliber .30, have, during the year, been made, and tested by firing, from steel submitted by the Benj. Atha & Illingworth Company, of Newark, N. J., and by Messrs. Spaulding, Jennings & Co., of Jersey City.

From the former were used one lot supposed to be crucible steel and a sample of nickel steel numbers 6 and 12 in the table; from the latter were tried a steel that had been subjected to some special treatment not explained and a sample of nickel steel, the last two numbers 8 and 10 in the table.

The four barrels made from the above steels were all tested in the same manner; 1,010 rounds of 36 grains of Wetteren powder and 230 grains of bullet were fired from each; velocities were taken with the first ten shots and after the two hundredth, four hundreth, sixth hundredth, eight hundredth, and one thousandth round from each barrel. With all, the results were practically the same; between the first and last round the velocity of the projectile fell off from 80 to 90 feet, nearly all of which occurred between the first and six hundredth round, to the extent of at least 30 feet from the first to the two hundredth fire, and the same amount before the four hundredth round was reached.

This is accounted for by the enlargement of the chamber, due to insufficient elasticity in the metal and to erosion of the bore near the chamber, from the smokeless powder.

It is possible that with the new powders, in order to obtain the most satisfactory results, there will have to be sought a quality of steel different from any so far tried at this armory.

INVENTIONS FOR MAGAZINE SMALL ARMS.

On January 9, 1893, there was received at this office the following letter of instructions with circular letter:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, D. C., January 7, 1893.

SIR: I inclose copies of a circular letter prepared for the information of inventors who desire to submit improvements in magazine small arms for examination and test by the Ordnance Department.

The object sought in thus aiding inventors is to neglect no means of improving the arm lately adopted for our military service, or of obtaining a better arm. You will therefore have expert examination made of inventions and improvements presented to you, and submit reports on the same, as proposed in the circular letter. If a sale of material by the Government is involved, a report, with your recommendation thereon, should be made to this office for authority to make the sale.

It is not intended as a rule that firing tests will be made in this preliminary expert examination of inventions unless such tests are found to be necessary in order to arrive at an opinion, and they will not be made, or if begun, the firing tests will be discontinued, if the examination shows clearly that the invention does not possess such merit as to lead to the belief that further trials would eventually result in any improvement to our service arm.

If the examinations show no special merit in the invention, the only report required at this office is simply a statement that an invention, improvement or arm, giving its name and the name of the presentor, was examined and found not to possess such merit as to warrant a report thereon.

Full and careful reports will be made of all inventions that are found to possess merit described herein and in the circular letter, especially of such inventions as receive firing tests, and the views and recommendations of the commanding officer of the armory are desired thereon.

A final trial of meritorious inventions before a board of officers to be organized for that purpose will be made the subject of future consideration.

Respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The COMMANDING OFFICER, SPRINGFIELD ARMORY.

[Circular letter.]

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, January 2, 1893.

Information for inventors desiring to submit improvements in magazine small arms for examination or test by the Ordnance Department, U. S. Army.

The Board on Magazine Arms, convened by General Orders No. 136, Headquarters of the Army, Adjutant-General's Office, November 24, 1890, examined and tested fifty-three guns, and selected one, which, having been approved by the War Department, now constitutes the service pattern. The duty for which that board was convened being terminated, the board was dissolved by the War Department orders of September 26, 1892.

It is the purpose of the Chief of Ordnance to establish, as follows, regulations for an expert examination and test of improvements which may be presented, to such an extent as will determine the merits of the invention for the military service by comparison with the arm in use, or those previously tested, and at the same time assist inventors in developing their improvements and in perfecting such as appear to be meritorious.

Consideration will be given only to arms or improvements adapted for use in the military service, and, unless otherwise specially authorized by the Chief of Ordnance, only to such also as pertain to an arm of the present service (.30) caliber. No restrictions are imposed as to the number of cartridges that the magazine will contain, or the form of cartridge, whether with flanged head or rimless and cannelured. These are regarded as open questions, to be left to the discretion of the inventor, and which, if embodied in an arm presented for examination or trial, will receive due consideration in the determination of the merits of the arm as a whole.

The information furnished by inventors and the reports of examination of inventions will, if desired, be held as confidential.

1. The expert examination or tests herewith provided for will be made at the Springfield Armory, and in general the merits of the improvement presented will be adjudged in comparison with the service rifle and the record of the recent Board on Magazine Arms.

2. An inventor may submit in person to the commanding officer of the armory for preliminary examination any arm, or invention bearing thereon, or any design upon which he may desire to receive information or to obtain informally an expression of opinion with the view of learning what may be of use to him in preparing a fire-arm for the military service, to be presented subsequently for official report or test.

3. When a design for an arm or improvement is submitted which, upon examination, is considered as offering a reasonable hope of being developed into an arm possessing features superior to those of arms in use or previously tested, then assistance will be given to the inventor by selling to him, at cost price, any finished or partially completed parts of any arm or ammunition made by the Government that he may desire, but the Department will not otherwise undertake to manufacture or repair any arm or parts thereof for private parties.

Descriptions and drawings of designs or models which are submitted for examination, and the patent specifications, if taken out, must be furnished in duplicate, one copy to be retained for file at the armory.

4. When an arm ready for trial is presented at the armory by an inventor, or his representative, it will be subjected to a critical expert examination regarding its merits, and the report of the examiners, with recommendations thereon by the commanding officer of the armory, will be forwarded to the Ordnance Office. Accompanying this examination, and for the purposes of the report, the arm will, in the discretion of the commanding officer of the armory, be subjected to such firing tests as pertain to the ordinary conditions of service, but no extraordinary conditions, such as rusting, dusting, etc., will be imposed. The arm will not be subjected to firing tests when careful consideration of the parts makes evident defects or weaknesses or features undesirable in a military arm.

5. As respects those arms which were submitted to the recent Board on Magazine Arms, the merits of which have already been determined under the most thorough system of examination and test that the Department can organize, and also such as have been previously tested at the Springfield Armory, the inventors are advised that in order to make any one of these arms a proper subject for further examination or test by the Department the objections to defects which were developed by the previous trial should be met and remedied, or it should be shown that substantial and radical improvements have been made.

The firing tests of any of these arms which may be resubmitted for the expert examination before mentioned will, as a rule, be confined to the points of defect developed in their previous trial.

6. The ammunition required for these tests, if of service pattern, will be supplied by the Government.

It is desirable that the inventor should be present when firing tests of his arm are in progress.

7. Arms and improvements which, as a result of their examination, as provided for above, and the reports thereon, are deemed by the Department to possess sufficient merit to warrant the expense of an exhaustive trial, may then be submitted by the Chief of Ordnance to a board of officers organized for the purpose for a final consideration and determination of their merits under tests similar to those made by the recent Board on Magazine Arms.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

In accordance with the foregoing letters, drawings, and descriptions, and in a few cases arms, have been received by the commanding officer for his consideration. Some of these have been referred from the Ordnance Bureau.

Excepting letters of inquiry, the principal papers received and the action taken on each were as follows:

January 16, 1893.—James M. Fish, of Coolidge, N. Mex., writes relative to a magazine gun which he wants tested with a view to adoption by the Army.

Referred from Ordnance Office. "A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been informed that he may send to him direct either the arm itself (if completed) for examination or the duplicate copies of papers mentioned in paragraph No. 3 of the circular, and await further advices before sending the arm."

April 14, 1893.—Returned to the Chief of Ordnance "with report that up to this date nothing has been heard at this office from the writer of the within letter.

January 16, 1893.—F. E. Phillips, of Montreal, Canada, claims that his magazine rifle is superior to others, and requests that the Department will examine it.

Referred from Ordnance Office. "A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been informed that he may send to him direct either the arm itself for examination or the duplicate copies of papers mentioned in paragraph No. 3 of the circular, and await further advices before sending the arm; also that the arm, if sent, must be delivered at the Springfield Armory free of all charges."

April 14, 1893.—Returned to the Chief of Ordnance, "with report that up to this date nothing has been heard at this office from the writer of the within letter."

January 16, 1893.—S. M. Houck, of Springfield, Ohio, inquires whether any decision has been reached in the matter of a magazine gun for the Army. Would like to submit plans of one of his designing.

Referred from Ordnance Office. "A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been

informed that he should send to him direct the duplicate copies of papers mentioned in paragraph 3 of the circular for examination."

April 13, 1893.—Returned to the Chief of Ordnance, "with report that up to this date nothing has been heard at this office from the writer of the within letter."

January 16, 1893.—George Elrick, of Joliet, Ill., desires to introduce a magazine rifle of his invention to the attention of the Department.

Referred from Ordnance Office. "A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been informed that he may send to him direct either the arm itself (if completed) for examination or the duplicate copies of papers mentioned in paragraph No. 3 of the circular, and await further advices before sending the arm."

February 18, 1893.—Returned to the Chief of Ordnance, "with report that the papers referred to in first indorsement have been received at this office and have been examined. The design submitted possesses no merit that would recommend an arm so constructed for use in the military service. One copy of Mr. Elrick's drawing and description is forwarded herewith."

January 16, 1893.—J. W. Mullins, Fariston, Ky., has remitted $3.75 for cartridges and expressage. Desires that February 1, 1893, be named as the time for sending this gun to Springfield Armory.

Referred from Ordnance Office, "with request to inform the writer when an examination or test of his arm can be made at the armory. The inventor claims that substantial and radical improvements have been made in his arm since its test by the Board on Magazine Arms. A copy of the Ordnance Office circular of January 2, 1893, has been sent from this office to Mr. Mullins."

July 3, 1893.—Returned to the Chief of Ordnance, U. S. Army, "with report that the rifle which Mr. Mullins desired to have examined was received at the armory on the 23d instant, with drawings and description.

"A careful consideration of this device shows that it possesses no merit as a magazine arm, and as a single fire-arm is inferior to other known patterns.

"The magazine can be loaded only when the bolt is withdrawn, is then charged with difficulty, will hold but four cartridges, and there is no provision by which only one cartridge may be fed at a time into the receiver.

"The cut-off is badly placed and is insecure.

"The extractor and the means of ejecting the shell are novel, and with the arm presented do not work with certainty. This may be due entirely to the poor workmanship of the arm.

"The mainspring is compressed as the bolt is closed, which is an objectionable feature.

"The arm is not provided with a 'safety lock.'

"The drawings and description are forwarded herewith; the arm is retained at this office."

January 16, 1893.—O. B. Greeves, Beaumont, Tex., desires to submit to the Board on Magazine Arms his improved rifle, fitted with interchangeable mechanism, carrying 24 cartridges.

Referred from Ordnance Office. "A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been informed that he may send to him direct either the arm itself for examination or the duplicate copies of papers mentioned in paragraph No. 3 of the circular, and await further orders before sending the arm."

February 28, 1893.—Returned to the Chief of Ordnance, "with report that Messrs. Greeves and O'Neill, of Beaumont, Tex., have sent to this office a drawing and description, said to be duplicates of those furnished the Bureau, of the arm referred to within.

"These papers have been carefully examined, and from them it is evident that the invention submitted does not possess sufficient merit to warrant further report, and does embrace features not suited to a military fire-arm.

"The inventors have been advised that a report has been made to the Bureau."

January 16, 1893.—J. C. Lodor, J. G. Barri, Wilmington, N. C., inclose blue print and description of their automatic fire-arm.

Referred from Ordnance Office, "for report under letter of instructions from this office dated January 7, 1893.

"A copy of the Ordnance Office circular of January 2, 1893, has been sent to the writer, who has also been requested to send to him direct a duplicate copy of the papers, as required by paragraph No. 3 of the circular."

January 28, 1893.—Returned to the Chief of Ordnance, "with report that careful examination has been made of the drawings and description of the Lodor-Barri Automatic Fire-arm, and the device is found not to possess such merit as would warrant the construction of an arm or even of a model for further consideration as a weapon for military purposes.

"This report has been deferred till after the receipt of the duplicate copy of papers referred to in first indorsement."

January 23, 1893.—Austrian Arms Manufacturing Company have furnished three samples of their 6.5-millimeter caliber rifle, model 1892, of the same instead of three different models, as desired; also send 500 sharp and 60 practice cartridges for experiment. Inclose pamphlet description of this repeating rifle, and offer their services for fabrication of some 30,000 of said rifles, etc.

Referred from Ordnance Office, "for examination and test of the arms when received and for report under instructions contained in letter of January 7, 1893, from this office.

"These arms were ordered by A. Kline of the Austro-Hungarian Agency, 529 Broadway, New York City, on his responsibility. A copy of a circular letter of January 2, 1893, relative to the tests of magazine small arms has been sent to Mr. Kline, and he has been informed that the arms must be delivered at the armory free of all expense to the United States."

July 10, 1893.—Returned to the Chief of Ordnance, "with report that the arms referred to in first indorsement were received at this armory on the 3d instant.

"They are three Mannlicher rifles, caliber 6.5 millimeters, all alike, probably the latest model. They differ from the rifle received from the Bureau and reported upon March 10, 1893, Ordnance Office file 3642 of 1892, only in the length of barrel, which is 2½ inches shorter, in the upper band, in two of the sling swivels, in the sight, and in the bayonet. None of these changes are of any marked importance.

"As these guns differ in no essential feature from the Roumanian rifle, which was thoroughly tested by the first Board on Magazine Arms, it has not been considered necessary to make a further test of the system.

"The three rifles and the ammunition are held at the armory for further instructions."

January 25, 1893.—B. Friend, Chicago, Ill., says he has a model of an entirely new magazine rifle, but it has been constructed upon the measurements of a foreign ammunition; therefore was not submitted. Desires to obtain two rifle barrels with a supply of the ammunition for the purpose of having a new gun made to submit for inspection.

Referred from Ordnance Office, "with instructions to communicate with the writer with a view to an examination of his plans for a magazine gun, and thereafter to return this letter with his recommendation as to the sale of the barrels asked for under existing instructions for the examination and test of new magazine arms."

April 14, 1893.—Returned to the Chief of Ordnance, "with report that on January 28, 1893, a letter was addressed from this office to Mr. Friend informing him that an examination would be made of his designs, device, model, or arm whenever he might send them."

"Up to this date no reply has been received to that letter."

February 6, 1893.—J. P. Lee, Hartford, Conn., having made some changes in his arm, he thinks the ordinary cartridge can be used, and desires to purchase 500 cartridges, latest pattern sight, and a wood cover for same.

Referred from Ordnance Office. "Copy of the circular of January 2, 1893, has been sent to Mr. Lee, and he has been requested to communicate with you in relation to his new magazine small arm."

March 2, 1893.—Returned to the Chief of Ordnance, "with report that Mr. Lee has visited the armory to-day, exhibited his gun, and now desires to purchase 1,000 cartridges to use in a preliminary trial to be made by him."

February 15, 1893.—John Henry Blake, New York, N. Y., has shipped magazine rifle for examination, etc.

February 16, 1893.—Reported to the Chief of Ordnance, U. S. Army, "that in accordance with the provisions of your circular letter of January 2, 1893, Mr. John H. Blake has sent to this office a rifle of similar construction to that presented by him to the Board on Magazine Arms.

"He claims that certain changes have been made which will overcome the defects recorded by the board in its report. As the arm embodies features which render it unsuited to use in the military service, it is presumed no further action is needed.

"Mr. Blake has been advised that a report on the arm has been made to you."

February 16, 1893.—F. A. Bill, Springfield, Mass., incloses papers in regard to a magazine arm invented by Mr. Wm. S. Teall, in care of S. B. Newman & Co., Knoxville, Tenn.

February 17, 1893.—Mr. Bill informed "that Mr. Teall's ideas are so far behind the present needs of fire-arms for the military service that there is no feature which might be of value."

April 4, 1893.—Henry D. Macdona, attorney for Bethel Burton, New York, N. Y., forwards description and drawings, in duplicate, of magazine arm under the "January circular letter," and makes application for two barrels and a quantity of cartridges.

April 8, 1893.—Reported to the Chief of Ordnance, "that in accordance with the provisions of your circular letter of January 2, 1893, Mr. Henry D. Macdona, attorney for Bethel Burton, of Brooklyn, N. Y., has sent to this office drawings and description, in duplicate, one copy of each of which is forwarded herewith, of a magazine rifle."

Mr. Macdona asks that "two Government barrels and a quantity of

Government cartridges" be furnished, to enable an arm to be made suitable for competition.

Examination and careful consideration of the design submitted shows that it possesses no merit that would recommend an arm so constructed for use in the military service.

Some of the objectionable features, evident from the drawing and description, are—

(1) A large, cumbersome magazine.

(2) The carrier having to move the entire depth of magazine before and after each shot.

(3) The folding arms beneath the carrier plate.

(4) The lever by which carrier is operated.

(5) Cartridges fed by gravity alone.

(6) Apparent want of means to prevent cartridges from impeding motion of carrier.

(7) The guide to prevent rotation of bolt.

(8) The interrupted screw for locking bolt instead of a simple lug, as in many arms.

(9) The absence of an extractor and an ejector, or if certain lines on drawing do represent the former, it will have to turn with the bolt.

"Mr. Macdona has been advised that a report on the design has been made to you."

June 5, 1893.—W. W. Harris, Sioux City, Iowa, addressed recorder, Board on Magazine Arms, and sends drawings, descriptions, etc., of a magazine arm.

June 5, 1893.—"Submitted to the Chief of Ordnance, through the commanding officer Springfield Armory, the Board on Magazine Arms having adjourned on May 16, 1893.

"Mr. Harris has been informed of this reference."

June 6, 1893.—Forwarded to Bureau.

COLUMBIAN EXPOSITION.

In July, 1892, instructions were received to prepare for the Columbian Exposition at Chicago a collection of machines illustrating the manufacture of the Springfield rifle, and such arms, specimens, and other articles as might be selected by Capt. A. H. Russell, Ordnance Department.

The programme as finally approved embraced machines that should perform the following operations, viz:

First turning butt of stock.
Bedding barrel in stock.
Planing stock.
Bedding lock in stock.
Bedding guard in stock.
Drilling barrel, caliber .30.
Second turning, barrel.
Rifling barrel.
Milling guard.
Profiling guard.
Clamp milling, tang screw.
Polishing wheels.
Rotary filing and polishing receiver.
Gas furnace and blower.

All of the above were overhauled, put in thorough working order, cleaned and painted and equipped with shafting, pulleys, hangers, and belting.

A heavy framework of timber was made and supplied with the line

shafting necessary for running all the machinery sent from the armory and also that from Frankford Arsenal. This framework was prepared so as to be readily set in position at the Exposition, and workmen were sent out from the armory who installed the entire plant and put it in running order. A collection of arms and other materials, and sample boards exhibiting the progressive stages in the manufacture of some of the principal parts of the Springfield rifle, were prepared and sent out.

Upon the opening of the Exhibition 8 workmen were supplied from the armory to operate the machinery; these are still in Chicago, and will probably remain there during the continuance of the Exposition.

Respectfully, your obedient servant,

A. MORDECAI,
Colonel, Ord. Dept., U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4771-'93.)

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[Advertisement.]

PROPOSALS FOR STEAM-POWER PLANT.

SPRINGFIELD ARMORY, MASS., *May 2, 1892.*

Sealed proposals, in triplicate, will be received at this armory until 12 o'clock m., on Thursday, June 2, 1892, for furnishing a steam-power plant, comprising steam-engine, boilers, etc., and for the delivery and erection of same in complete running order in the new shops at the armory.

The Government reserves the right to reject any and all proposals or parts thereof. Specifications and all other information can be had on application to

Col. A. MORDECAI,
Ordnance Dept., U. S. Army, Commanding.

[Read this carefully before filling out your proposal.]

INSTRUCTIONS TO BIDDERS.

SPRINGFIELD ARMORY, MASS., *May 2, 1892.*

1. This paper is published under the newspaper advertisement dated May 2, 1892.

2. Proposals must be made in triplicate, and this form must be used. It is further required that these proposals be signed with the full name and place of business of the bidder in the spaces provided on the following blank form.

3. Alterations by erasures or interlineations should not be made, but if unavoidable such change must be explained over the signature of the bidder, or new blanks called for, time permitting.

4. When a firm is a bidder, the member thereof who signs the firm name to the proposal must state in addition the names of all its members.

5. Any one signing the proposals as the agent of another, or others, must file with it legal evidence of his authority to do so.

6. The bidder must furnish satisfactory evidence of his ability to furnish the materials and perform the work for which he bids.

7. The bidder to whom a contract may be awarded must execute the same in quintuplicate within ten days after receiving it, and also execute a bond in *not less than one-tenth* the aggregate of the contract on each copy of the contract, according to the form and in the sum prescribed.

8. The bonds are to be executed by the contractor as principal, and two responsible persons as sureties, under seal. Signatures of obligors and sureties must be attested by a separate witness to each when practicable. Seals to signatures on contracts and bonds must be of an adhesive substance.

9. Each of the sureties must make and subscribe to an affidavit of justification to the full amount of the bond, which must be followed by the certificate of a judge of

a United States court, a United States district attorney, or other civil officer of the United States, as to the sufficiency of the individual sureties.

10. A firm will not be accepted as surety for a partner, nor a partner for a copartner or firm of which he is a member, nor an officer of a corporation for such corporation.

11. In case a contractor fails to perform the stipulations of his contract in the manner and time specified, the United States may proceed against him or his sureties, or both, and charge any additional expense incurred by the United States in the completion of the work, in excess of the contract price, to the contractor or his sureties, or both.

12. Envelopes containing proposals must be sealed and indorsed "Proposals for steam-power plant," to secure them against accidental premature opening.

13. The United States reserves the right to reject any and all bids, or parts thereof.

14. Bidders will state the time within which they will furnish the plant for which they bid, set up in working order.

A. MORDECAI,
Colonel, Ord. Dept., U. S. Army, Commanding.

Specifications for a steam-power plant for shops at the United States Springfield Armory, Mass.

This steam-power plant is to consist mainly of a pair of compound condensing engines, four boilers, one feed-water heater, and two steam feed pumps; all to be placed in position in working order. A jack shaft with pulleys is also required. set up. The engines, heater, pumps, and jack shaft will be embraced under one proposal and contract; the boilers under a second proposal and contract. All must be erected in complete running order, steam and belt on in the shops at the armory, and be put in successful operation by the contractor before being turned over to the United States. Drawings showing dimensions of building and desired location of all parts of the plant, also any information required in making an intelligent and correct estimate, will be supplied upon application.

Bidders will furnish with their bid a general installation plan of the plant, showing the location and dimensions of the principal parts, also all pipe lines and such designs of engines, boilers, boiler setting, etc., as will enable a satisfactory judgment to be formed of the merits of the parts. A complete description of all parts of the plant, with a statement of any particular advantages claimed, must also accompany the bids. Photographs are desirable, but not absolutely necessary; cuts alone accompanying bids can not be considered. Anything required toward the erection and completion of the plant, all skilled and unskilled labor, all materials and tools, all transportation to the place of erection, all appliances for the execution of the work, and also all necessary drawings must be furnished by the contractor.

The engine-room floor and the boiler-room floor, of concrete, will be made by the United States. All excavations, foundations, and other masonry, all cutting or building up in walls or roof, except as set forth in specifications, will be executed by the contractor, and he will comply with the State and other laws during the performance of his contract, and be responsible for all injury and loss of life or limb to his employés. The ground beneath and around the buildings is sand.

Bidders will give the price for the whole work upon which they bid, and also of each of the principal parts; and they will state the time within which they will erect and put in successful operation the plant they propose to furnish. A penalty of $20 will be exacted for each and every day of delay over the contract time for the completion of the work, unless caused by unavoidable accidents or labor strikes.

Payment will be made in two installments of 50 per cent each; the first upon the delivery of the whole material at the building, and the second on the final acceptance of the work by the United States, after successful operation of the plant for 20 consecutive days.

ENGINE PLANT, ETC.

Engines.—A pair of compound condensing engines, right and left hand, with one fly wheel common to both, to be designed to run under a boiler pressure of 125 pounds per square inch, and to make not less than 60 nor more than 80 revolutions per minute. Each engine must be capable of developing under the most economical conditions 150 horse-power; the collective power of both engines being thus 300 horse-power, but the cylinders must be of ample proportions to develop 225 horse-power when required, without injury to any parts.

The engines must be arranged so that either one of the pair can be disconnected readily and the other one be run alone for any length of time. Generally one engine only will be needed to run the shops.

Bidders will state the dimensions of cylinders and the conditions under which their engines will fulfill the above requirements.

The engines must be guaranteed not to vary their number of revolutions per minute more than 1½ per centum above or below the prescribed normal speed, provided the whole load be not beyond the rated power.

Materials.—All cast-iron parts must be of first quality pig iron, containing not less than 25 per cent of charcoal iron, as hard as can be properly worked, and be free from all defects. *Crank shaft*, *piston rods*, all *pins*, *connecting rods*, *hooks*, and *eccentric rods* will be of first-class hammered open-hearth steel, free from imperfections. Bronze parts to be of a composition of 90 per cent copper and 10 per cent tin. Babbitt metal to be of first-class quality.

Cylinders.—Must be bored true, parallel, and smooth. They and the steam chests will be covered with some first-class nonconducting material, not less than 1½ inches thick, and will be lagged with nickel-plated sheet brass, neatly fitted, and trimmed with nickel-plated bands. Heads will be protected by a nonconducting covering and supplied with polished cast iron bonnets. *Valve gear* to be simple in construction, quiet and effectual in operation, and of the most improved design. Should the arrangement of the engine require a *receiver* between the high and low pressure cylinders, the bidder will so state.

Running parts.—*Frames* to be of the girder type of ample strength. Guide surfaces to be parallel and true with axis of cylinders. Main bearings to be not less than 9 inches in diameter and 18 inches long, and to be provided with adjustable quarter boxes, lined with Babbitt metal, hammered in place, and accurately bored and scraped to fit. *Connecting-rod boxes* and *crosshead shoes* to be Babbitt lined in the same manner. *Crosshead boxes* to be of bronze. *Crossheads* to be of the solid pattern with adjustable shoes, presenting a working surface of not less than 110 square inches. *Crank shaft* to have not less than 9 inches diameter in bearings and not less than 12 inches in wheel seat. *Cranks* to be cast solid without chambering or coring, to be pressed on the shaft, and to be securely keyed.

Fly-wheel to be of proper diameter to run a pulley on jack shaft of 10 feet diameter by 42 inches face at a speed of 100 revolutions per minute. It is to have 42-inch face, turned crowning for a 40-inch double belt. Its weight when finished must not be less than 32,000 pounds, and it may be made either in sections or in halves. If made in sections, the arms must be of ample proportions; all parts must be properly fitted together, and segments, arms, and hubs must be securely connected by means of keys and body-fitting turned bolts. If made in halves, it is to have a double set of heavy arms, with hub of not lesser length than face of fly-wheel; partings to be planed. The wheel will be keyed to shaft by means of two keys.

The governor to be of modern design, simple, and of such construction as to maintain the normal speed of engines under any variations of load. *Throttle valves* to be fitted with easing valves, admitting steam from boilers automatically through a small opening, and relieving the main valve of the pressure. All running parts of engines to be provided with stationary automatic *oil cups*. *Stands* and *wipers* to be provided where necessary.

The engines will be set on cast-iron *base plates*, having an *oil tray* around each plate to catch oil dripping; or some arrangement equally neat and clean will be provided.

Condenser.—The condensing apparatus is to consist of a *jet condenser* and *air pumps* (driven from engine). Pump to be brass lined and brass fitted throughout; rubber valves to be of best quality. The apparatus should maintain in exhaust a vacuum of about 27 inches when engines are developing full power.

Instruments.—Each cylinder is to be properly piped and fitted with three way cocks for steam indicator. All such pipes and fittings to be nickel plated. An ornamental wooden frame is to be erected at a suitable place, containing a *clock*, a complete set of *steam* and *vacuum gauges*, Ashcroft or equal, and a *revolution counter;* all to be suitably connected with engines by brass pipes and rods, nickel plated where in sight. Gauges to have 10-inch dials, and to be in heavy brass cases, nickel plated.

There must be furnished one *"Tabor" steam engine indicator* complete, with a double set of extra springs; also a *pantograph*.

There will be one *single bell steam chime whistle*, 10-inch bell, properly secured above top of roof of engine room; it must be suitably connected with the live-steam pipe leading to engines and have a valve at the junction to prevent condensation in the whistle pipe; the pull to be in engine room.

Feed water heater.—There will be furnished and set up in the boiler room, complete with all connections, a feed-water heater, "Wainwright's," or equal, of ample size for a boiler capacity of 700 horse-power.

Piping.—The contractor is to provide all *steam* and *water connections* required for the proper operation of the engines. The main steam pipe from boilers will be brought close to the partition wall between the boiler room and the machine shop by the contractor for the boilers. The contractor for the engines will make from

the above-named wall, through the basement of the machine shop the live-steam connections to the engines, arranged so that the engines may be run independently.

The *exhaust pipes* will be connected with the condenser; *back-pressure valves* of approved make will be interposed at suitable points. Provision must be made to enable the engines to be run at any time with or without condensation; for this the *exhaust pipe* will be taken through the basement of the machine shop into the boiler room, and be connected there to the feed-water heater.

From the heater the exhaust pipe must be carried through the roof of boiler house, terminating at a height of about 3 feet above the roof, and be provided with a head of sheet copper of approved construction. All live and exhaust steam pipes will be flanged, will be of cast-iron (except that portion of the exhaust pipe leading from feed-water heater to roof, which may be of wrought iron), thick, and of ample dimensions. Bidders will state diameter and thickness of metal of pipes. Flanges will be faced and will be connected, steam tight, by means of gaskets and screw bolts. All pipes will be tested by the contractor under a warm-water pressure of 250 pounds per square inch. Proper provision will be made for expansion in pipe lines, and pipes will be supported suitably by means of roller hangers, or roller saddles, wherever bearing on walls or on piers.

A water pipe for the condenser supply will be brought by the Department to the inside of the wall in basement of engine room, at a point indicated on the plan, and the contractor is to make all water connections between that point and the condenser and pump. These connections to be of heavy, cast-iron pipe, with faced flanges.

Feed pumps.—There must be furnished and erected in boiler room, adjoining the feed-water heater, and as close as practicable to partition wall between boiler room and machine shop, two first-class boiler steam-feed pumps of approved construction, and each one of ample size for 700 horse-power boiler capacity. Contractor is to make proper water connections from the main water pipe in engine room to feed-water pumps, and from pumps to feed-water heater. Provisions must be made in feed-water pipes at two suitable points, before reaching and after leaving pumps, that connections can be made for filling boilers, and also for supplying feed water from pumps to boilers direct without passing through heater, and valves must be provided at these points. A suitable relief valve must be interposed in discharge pipes of pumps, allowing feed water to be returned into suction pipe in case the pump is running while the feed to boilers is shut off.

Drips.—All pipes, of whatever character, must be properly dripped, also the steam cylinders of engines, bottom of feed-water heater, and exhaust head. All drips must be carried into the sewer by the contractor. The location of the sewer is indicated in plan. The blow-off pipe from feed-water heater also will be carried to sewer. Exhaust pipe from steam pump to be carried into main exhaust from engines where joining the feed-water heater.

Fittings.—All wrought-iron pipes to be lap welded. All valves to be gate valves. All fittings to be heavy, of cast iron, except where brass fittings are required. Steam valves, 3 inches and upward, to be "Chapman," or equal, extra heavy, with removable bronze seat. All other valves to be straightway asbestos disk valves. Water valves to be "Chapman," or equal. All valves below 3 inches to be of brass. Bidders to state kind and manufacture of feed-water heater, pumps, and valves, on which their bid is based. All live and exhaust steam pipes (except that portion from feed-water heater to roof of boiler room) to be covered with "magnesia" sectional covering, which is to receive two coats of oil paint of such color as the commanding officer may direct.

Jack shaft.—There is to be furnished and erected in place in basement of machine shop a jack shaft with all necessary bearings, couplings, collars, and pulleys, as shown on plan. The shaft is to be $5\frac{5}{16}$ inches in diameter, in two pieces of such lengths as shown in drawing. The shaft is to be made of first-class open-hearth steel, accurately turned and polished all over. It is to be supported on 7 adjustable pillow blocks, with babbitted self-oiling boxes, bored and reamed out. Pillow blocks to be of ball-and-socket type and to rest on heavy pedestal plates, provided with set screws for sidewise adjustment. The pedestal plates to be anchored to foundation masonry with bolts of $1\frac{1}{2}$ inch diameter, while pillow blocks are secured by bolts to pedestal plates. Couplings to be keyed to shaft, to be of the flange type, with reamed holes for taper bolts.

Three pulleys are required, one of 10 feet in diameter and 42 inches face, and two of $7\frac{1}{2}$ feet diameter and 32 inches face. All to have heavy rim, heavy double arms, and clamp hubs. Bore of hubs to be slightly smaller in diameter than diameter of shaft. Pulleys to be keyed to shaft, to be turned crowning, and to be carefully balanced.

The contractor is to furnish and to put on so as to drive from fly-wheel of engine the corresponding pulley on jack shaft one heavy double leather belt, 40 inches wide; to be made of pure oak-tanned leather, free from centers, necks, or flanks; to weigh not less than 32 ounces to the square foot in any part, and to be put on endless. It may be made of cotton leather belting; if so, must be stated in bid.

Foundations.—The steam engines, feed-water heater, steam pumps, and the jack shaft will be erected by the contractor on masonry foundations of proper dimensions. These foundations must be clearly shown in the installation plan of the contractor, except the foundation masonry of the jack shaft, which will be made in accordance with drawings furnished by the Department. There are no excavations required for any foundations except for the jack shaft, which must be made by the contractor without extra charge.

The foundations for the engines must begin on the present floor line of the basement of the engine room. First a base will be made, 18 inches thick, of concrete, to be mixed in the proportion of one part of Portland cement to two parts of sand and five parts of broken stone. The sand must be clean and sharp, the broken stone of such size as will pass through a 1½-inch ring. The concrete is to be properly mixed and rammed before setting, until the water flushes to the surface.

The foundation of the jack shaft is to commence on a concrete bed of 12 inches thickness, and that for pumps and feed-water heater on a concrete bed of 6 inches in thickness. The remainder of the foundations is built of brickwork, laid in hydraulic cement mortar, mixed in equal parts of best Portland cement and sharp clean sand. No mortar must be used after it has once set. All brick must be of first-class quality, burned hard throughout, and must be laid with close joints; no bats shall be used.

The brick masonry for the steam engines must be capped with stones of good sound granite, dressed square and true, and not less than 16 inches thick; bottom to have a point finish, top and sides to be dressed perfectly smooth and level. Holes for foundation bolts to be drilled through square with face of stones. The cap stones for pedestal plates of jack shaft are to be of such dimensions as shown in drawing, while those for heater in pump and boiler house shall be of adequate dimensions. All stones to be carefully and neatly bedded in Portland cement. Any work necessary on the partition wall between engine room and machine shop in connection with the required passage of the main driving belt will be performed by the Department, also all work in connection with the removal of certain wrought-iron beams forming engine room floor.

Finishings.—All unfinished work of the engines is to be heavily primed, filled, and rubbed down, to produce a smooth surface. The final coat will be of such color as directed by the commanding officer; it will be varnished and rubbed down to a dull polish. The contractor will furnish and set up a polished brass railing, with suitable stanchions, bases, and sockets around the crank end of each engine and around the fly-wheel and driving belt.

BOILER PLANT.

General conditions.—The *steam boiler plant* is to consist of four boilers, arranged in a row, and located as shown in drawing. They may be of the *horizontal tubular type* or may be any *water tubular boilers* of tried construction and well-proved capacity. Whatever may be the type offered, the capacity of each boiler under ordinary working conditions must be stated, and a sheet will be submitted showing the calculations by which such capacity was determined. Any type of boiler furnished must be erected in accordance with the provisions of the following specifications for horizontal tubular boilers, so far as they may apply to boilers of the type offered.

It is desired that the boilers shall be of the greatest capacity consistent with the space assigned for them. An aggregate of about 700 horse-power is preferred. As arranged, they should not occupy in width a floor space materially greater than that indicated on plan. A somewhat greater length is permissible, provided there remains such space in front of the boilers as is consistent with the proper operation of the plant, and the possible removal of one boiler for repair, without disturbing the others. Proper consideration must be given to the accessibility of all parts for cleaning and repair. The plant complete must be delivered in working order with steam on. The United States will do all necessary cutting and building up in wall, chimneys, and roof, but nothing more.

Horizontal tubular boilers.—If of the horizontal tubular type, the boilers must be 72 inches in diameter and 17 feet long, with a steam dome 36 by 36 inches, placed in center of the middle course.

Tubes.—Each boiler should contain 104 3½-inch tubes, either of wrought iron, best lap-welded, or of steel, seamless drawn, each 17 feet long, set in vertical and horizontal rows, with a clear space between them of 1 inch, vertically and horizontally, except the central vertical space, which shall be 2½ inches wide; the center of top row of tubes to be 10 inches above center line of boiler. Tube holes through heads to be neatly chamfered, and to be set with a "Dudgeon" expander. The ends of the tubes to project beyond heads ⅝-inch, and to be flared but not beaded over. The space between tubes and shell must not be less than 2 inches. Should a different arrangement of tubes be proposed, the aggregate heating surface in the tubes must not be less than for a boiler with tubes as above.

Material of shell.—First-class open-hearth fire-box steel of domestic manufacture will be required for the shell and heads of boilers and domes Shell of boilers to be in three courses, each one sheet in length, seam of first course lapping away from fire. Lower half of first course to project 16 inches from tube sheet; this projecting part to be dripped; front and back heads to be of same diameter; all extra laps to be trimmed off; shell of boilers to be $\frac{1}{2}$-inch thick; shell of domes to be $\frac{7}{16}$ inch thick; heads of boilers to be $\frac{5}{8}$ inch thick, and heads of domes to be $\frac{1}{2}$ inch thick.

All this material to have a tensile strength of not less than 55,000 pounds nor more than 60,000 pounds per square inch of section, with not less than 55 per cent of contraction of area at point of fracture and an elongation of not less than 25 per cent in a length of 8 inches. All plates must be plainly stamped with name of maker, brand, and tensile strength; brands so located that they may be seen on each plate after the boiler is finished. Each shell plate must bear a coupon which shall be sheared off, finished up, and tested in the Government testing machine at Watertown Arsenal, Mass. The coupons must be stamped with numbers corresponding to numbers of sheets from which they are taken.

Tests will be made at Government expense, and contractor will forward coupons for that purpose to the commanding officer of the Springfield Armory. Each coupon must fulfill the above requirements as to strength and ductility, and must also stand bending down double when cold, when red hot, and after being heated red hot and quenched in cold water, without signs of fracture. Any and all plates failing to pass these tests will be rejected.

Riveting.—The longitudinal seams of these boilers must be of the triple-riveted butt-joint type with double covering strips. They must be arranged to come as near as possible above the horizontal plane through the center of boilers, and must break joints in the different courses in the usual manner. Flange seams of domes (at junction with shell of boiler), also vertical seams of domes to be staggered riveted. All girth-seams to be lapped and single-riveted. The boilers to be riveted with $\frac{7}{8}$-inch rivets throughout, which must be of ample length to form up heads equal in strength to the pressed heads of same. All rivets to be spaced $2\frac{3}{16}$ inches between centers. The preference is for drilled holes; if drilled they must be neatly chamfered $\frac{1}{32}$ of an inch on the faying sides of plates and covering strips.

If the holes are punched, each shell plate and head must be thoroughly annealed after punching, and the rivet holes must be chamfered sufficiently to remove any burr that may be formed in punching. No rivets shall be driven in unfair holes; such holes must be brought in line with a reamer. No drift-pins must be used in the construction of the boilers. All flanges to be turned in a neat manner to a radius of 2 inches, and to be clear of flaws, checks, and hammer marks.

Bracing.—There must be at least thirty-six braces of 1 inch diameter in each boiler above the tubes, 18 on front head and 18 on back head, of solid crow-foot form. Braces to be equally distributed on heads. None of them shall be less than $3\frac{1}{2}$ feet long, and those of the lower row to reach to second course of shell, care to be taken to leave space for access to boiler between braces, beneath manhole. Each brace must be fastened to shell and heads by two $\frac{3}{4}$-inch rivets at each end. Care must be taken in setting them that they may have uniform tension. Domes to have four $2\frac{1}{2}$ by $\frac{1}{2}$-inch flat-iron, crow-foot braces about 12 inches long, reaching from shell of boiler to shell of dome to reinforce the flange-seam, riveted with two $\frac{3}{4}$-inch rivets at each end. Head of domes to be braced to shell by six 1-inch crow-foot braces.

Openings.—The boilers to have a cast-iron manhole mouth-piece 11 by 16 inches (extra heavy), securely riveted to shell of boilers on top of rear course (back of dome), and to be furnished with cover and fastenings. Another manhole, 11 by 15 inches, is to be cut into front head of boilers below tubes, and is to have a stiffening ring of 2 by $\frac{5}{8}$ inch flat iron, riveted around same. A manhole cover of cast-iron and proper fastenings to be furnished to this manhole. A cast-iron frame to be set over top manhole of 24 inches interior diameter, with its lower extremity fitting on shell of boiler, while its upper end is to project above top of arch, is to be provided for each boiler, and is to have a cast-iron slip cover on top. This cover to have suitable handles for its removal for access into boiler. Two openings, 10 inches diameter each, 16 inches centers, to be cut girthwise into shell of boiler, beneath dome.

Each dome-head to be provided with two cast-iron flanged nozzles, one 6 inches internal diameter for steam pipe connection and one 6 inches internal diameter for safety-valve connection, both to be faced and drilled on top flange, and securely riveted to dome-head behind each other, the safety-valve to be in front. Drip holes must be placed at or near junction of shell and dome. Each boiler to be provided with a fusible plug in back head, 2 inches above top of upper row of tubes.

Valves, etc.—Each boiler to have a nickel-seated Ashcroft pop safety valve 5 inches in diameter, securely bolted to nozzle on top of dome; one nickel plated 8-inch Ashcroft steam guage, with syphon and stopcock; one combination water column, with $\frac{3}{4}$-inch guage glass and three $\frac{3}{4}$-inch gauge cocks; the steam and water connections between it and boiler must be made by pipes not less than $1\frac{1}{2}$-inch

diameter; one 2-inch brass asbestos blow-off cock; one 6-inch brass stop valve of approved pattern, securely bolted to nozzle on top of boiler; one 2-inch brass valve to be connected with blow-off pipe, above blow-off cock. Valves must be interposed between water column and boiler, in steam and in water connections. The kind and make of all valves will be stated; they must be of the best kind; those of 2 inches or less to be asbestos disk valves.

Castings for setting.—The boilers must be provided with a full cast iron front of neat design for all four boilers, with (double) flue, furnace, and ash pit doors with all necessary fastenings; metal of castings to be not less than $\frac{3}{4}$ inch thick. The flue doors to project from main face of front (dished), and corners to be well and nicely rounded. They must have a perforated cast-iron lining-plate, fastened to each wing in such a manner that face of lining-plates may be about in same plane with face of front. Doors to be properly fitted and chipped, to have a uniform bearing against their faces. Furnace doors (36-inch) and frames must be of Ashcroft-Martin's balanced furnace door pattern, as manufactured by the Ashcroft Manufacturing Company, Bridgeport, Conn. The front must have a suitable cornice on top and brackets for the reception of steam gauges and feed pipes.

The end column of front to be separate pieces, ⊥-shaped. Through these pieces go the necessary tie-rods to tie the brickwork transversely and longitudinally together and to hold the front. Tie-rods to pass front to rear must be also between each two boilers, located in interspace of masonry. No tie-rods must be built into the brickwork; they must be located on the outside, in recesses left for that purpose in the brickwork. The cross tie-rods in front to be on the inside of the cast-iron fronts. The whole front to be made in suitable sections, bolted together on the inside, and well ribbed on back to prevent warping and cracks. Joints to be covered. Fronts must be arranged so as to be able to remove any one of the boilers for repairs, or otherwise, without disturbing the others.

For each boiler must be furnished a back flue door and frame, about 16 by 24 inches. Dead plate to have a socket on each side for the reception of the special pillar tiles, supporting the arch tile over furnace mouth. Two heavy cast-iron return-flue lintels, 7 feet long by 18 inches wide and $1\frac{1}{2}$-inch thick, with a central rib 8 inches high, lengthwise, to cover return flue in rear of each boiler. A damper frame with cast-iron damper, about 22 by 32 inches, with chain, pulleys, and counterweight complete, is required for each boiler. Ten heavy backstays, with the necessary 1-inch brace rods, to be furnished to bind brickwork crosswise top and bottom; also all other tie-rods, washers, etc., and a strap anchor of 6 by 1 inch flat iron across rear wall of boilers.

Grates to be of proper size for bituminous coal, and to be of the Ashcroft-Martin type, as manufactured by the Ashcroft Manufacturing Company, Bridgeport, Conn., with square wrought-iron grate bars, heavy bearers; wrenches, and appurtenances required.

Each boiler to have at least six cast-iron brackets, securely riveted with six 1-inch rivets each to shell; brackets to be 12 inches long, with a projection of 12 inches from boiler, and to be in level with center line of top row of tubes. Cast iron wall plates, 24 inches long, 12 inches wide, and $1\frac{1}{2}$-inch thick, must be furnished for each bracket to rest upon, and three rollers 1 inch in diameter and 10 inches long, must be furnished for rear and center brackets to rest upon, to allow free expansion of boiler.

Flues.—The gases of combustion are carried over top of boilers to the back end, passing through dampers into flues of proper area and of form as shown in blue print, and thence into the chimney. These masonry flues must be properly supported on heavily ribbed cast-iron lintels on plates of ample strength, resting on rail bars, and on a girder of ample strength, supported on two heavy cast-iron columns and on a channel built into back wall of boilers. All must be properly anchored and secured. These plates must be covered with two courses of brick, laid flat, the upper course to be of fire-brick. The flues to be covered on top with ribbed plates of cast iron resting on masonry and of suitable form and size to cover flues up to chimney. These plates to be covered with two courses of brick laid flat. The space underneath flues and between back wall of boilers and partition wall and chimney forms a passage for access to rear of boiler for cleaning, etc.

Setting.—The boilers must be set in place with all connections and fixtures, castings, or ironwork of any description necessary for the proper setting of the boilers complete. All material and workmanship to be subjected to inspection, and anything not of proper quality or construction may be rejected by the commanding officer.

The boilers must be set in brick masonry, as indicated in blue print, by competent mechanics. Intermediate walls to have a 2-inch hollow space in center. All parts of masonry and flues exposed to flames or gases to be lined with No. 1 fire-brick, laid in best fire-clay and fire-sand, and properly banded to walls. Boilers, their connection, and setting, will be subjected to a rigid inspection and tests. The former

will be examined externally and internally by the inspector, and tested before leaving the shop of the maker with a warm-water pressure of 200 pounds per square inch. Working pressure of boilers to be 125 pounds per square inch.

Piping.—Each boiler to have a circular plate of shell steel 7 inches in diameter and ½-inch thick, riveted to bottom of shell 8 inches from back end, and tapped to receive a 2-inch blow-off pipe, which must be of brass, extra heavy, and covered with asbestos cloth from boiler to blow-off cock on rear end of back wall, thence of 2-inch wrought-iron lap-welded pipe leading to floor, where all blow-offs are connected with a 4-inch pipe leading through wall of boiler house and thence to the sewer. This 4-inch pipe is to be laid in a light cast-iron trough with cover (the latter level with floor) as far as inside of boiler house.

All necessary feed-water connections must be made from water main, from steam pumps, and from feed-water heater to boilers. The boiler feed pipe will be of 4 inches diameter and will run along and above front of boilers, and must be suitably supported. It will be connected with each boiler by a 1½-inch pipe securely screwed into the center of front head, 3 inches above the top of upper row of tubes. This pipe will run back to within 2 feet of the rear head, the end closed by a cap; as far as within the boiler it will be provided with three rows of ⅜-inch holes, 2 inches centers, drilled staggered, one row at bottom of pipe and one on each side at angles of 30 degrees; pipe to be properly hung from the braces. All parts of pipes located in furnaces or flues to be extra heavy, and to be heavily covered with asbestos cloth. The feed pipe to each boiler will be provided with a 1½-inch brass feed valve, and a 1½-inch brass check valve of approved construction; the feed valves will be located or arranged for convenient handling from floor of boiler room.

Provisions will be made to enable the contractor for the boiler plant to make three connections with the main feed pipe; one with the water pipe before reaching the pumps, one between pumps and feed-water heater, and one with discharge of heater. This arrangement is to permit of boilers being filled from main water supply direct, and fed by either pump forcing water through feed-water heater, or direct from pumps to boilers. All feed pipes from main water supply, pumps and feed-water heater to boilers to be of brass, seamless drawn, and all fittings to be of brass. All piping to be properly stayed and secured. A 1-inch brass water cock, threaded for rubber hose attachment, will be provided at a suitable point near front of boilers.

All drip pipes from gauge cocks to lead into a heavy cast-iron tank, 4 feet square by 3 feet deep, which is to be located as shown in blue print. This tank must be connected with the sewer (outside of building) by means of a 4-inch pipe; it will have a heavy perforated cast-iron cover, slightly dished, and the inlets and outlet will be near the top.

A cast-iron steam pipe of 12 inches internal diameter must be located above top of boilers, as indicated in drawings. Thickness of metal of this pipe to be 1½ inches. Pipe to have blank flanges at ends; four 6-inch flanged nozzles at the bottom, located so as to correspond with centers of boilers, and connected with steam stop valves of boilers by means of 6-inch copper pipes of S form, having brass flanges, and of ample thickness. The main steam pipe will have also two 8-inch nozzles at the side toward front of boilers; one of these to be provided with a blank flange, while an 8-inch cast-iron pipe, 1¼ inch metal, must connect with the other nozzle, and must be carried to partition wall between boiler room and machine shop, there to descend to a point above floor line, and to be carried through wall, all as indicated in drawing. All steam pipes, which are located higher than top of boilers, must pitch toward boilers. The steam pipes must be tested by the contractor with a warm-water pressure of not less than 225 pounds per square inch, before making connections. All connections to be by flanges, faced, and made perfectly steam tight; bolt holes to be drilled. Pipes to be covered with "magnesia" sectional covering, or equal.

Finishing.—Cast-iron floor plates, not less than 4 feet wide, made in suitable sections, must be furnished and laid along entire front of boilers; they will have a slight pitch toward the drip tank. All iron work of boiler fronts, flues, pipes, etc., not otherwise covered or in furnaces, will be nicely painted black.

There must be also furnished, *one crescent steam-tube cleaner*, and provisions for connecting it properly with steam for use must be made, and *one Christoffel's elliptic-spring steel* adjustable tube scraper for 3½-inch tubes, fitted up for use. For each boiler, one hoe, one rake, and one slice bar.

Bids.—Bidders will state price for each boiler complete, delivered at the armory, and also for the entire plant set up, complete with all piping and connections, ready for steam.

APPENDIX 12.

SPECIFICATIONS FOR TWO DWELLING HOUSES FOR OFFICERS, TO BE ERECTED AT THE SPRINGFIELD ARMORY, SPRINGFIELD, MASS.

(9 plates.)

GENERAL CONDITIONS.

The contractor is to give his personal attention to the work; he must provide an acceptable and competent foreman to take charge in his absence.

The dimensions and construction of the buildings and their various parts are to be taken from the plans and drawings furnished, and these are intended to coöperate with the specifications, so that any work shown on the drawings and not mentioned in the specifications must be executed as if fully set forth and described. The largest sized drawing of any part must be followed, and on small scale drawings the figures must be preferred to measurement by scale. Verify all figures and dimensions before using plans, in order to guard against mistakes in bringing the parts together. The drawings, printed copies, and specifications are the property of Gardner, Pyne & Gardner, No. 33 Lyman street, Springfield, Mass., the architects. They shall decide all questions relating to their meaning. They are to be used for these buildings only, and are returnable to them on the completion of the work. There must be no deviation from them, without the approval of the commanding officer. Unless otherwise specified, the detail drawings are to be used for both houses. The sideboard, furniture, shelving and drawers in the rooms, pantries and closets shown on the floor plans are not to be included in this contract.

The contractor is to keep a full set of the blue prints of the general drawings, and a copy of the specifications in an available place at the buildings at all times.

Unless otherwise specified, the contractor is to furnish all labor, transportation, material, apparatus, scaffolding and utensils needful for performing the work in the best and most thorough and workmanlike manner according to the true intent and meaning of the plans and accompanying specifications. All materials are to be new, except the old bricks furnished by the United States, and the best of their respective kinds, unless otherwise specified.

The work as shown by the detailed drawings and these specifications is to be done in all its details complete as so shown and specified, the same to be subject to inspection in detail during erection; and any materials or workmanship condemned shall be made good by the contractor before any further work is done; to be determined by the armory master builder and official in charge of the inspection, who are to have access to the buildings at all times, and they may require the dismissal of any workman deemed incompetent, objectionable, or careless, and the removal from the premises of any objectionable materials.

It is to be distinctly understood that the United States is not to furnish any material, transportation, or utensils, nor perform any labor except where so specified.

The contractor is from time to time to clear away and remove from the premises all dirt and rubbish, and cover and protect the work from all damage, and deliver the buildings whole and clean and in perfect condition.

The contractor is to comply with the Massachusetts State or other laws and such are to form a part of this specification, and is to be liable and pay for all penalties and all damages to life and limb that may occur through his negligence, faulty apparatus, or any cause, to himself, workman, or any person, or to the property of the United States.

The contractor will estimate upon employing his workmen eight hours daily and the hours of labor must coincide with those of the day in the armory. The commanding officer shall be privileged to employ workmen to execute any work not included in this contract without interference or hindrance from the contractor.

The contractor is to keep the building fully insured against loss or damage by fire, for the benefit of whom it may concern, and pay the requisite premium for same.

No person is to be recognized by the United States in connection with the furnishing of any material for the buildings and other work, or with work of building in any particular, but the contractor will be held responsible for both.

No money will be paid for materials, tools, transportation, or work of any kind, to any person, and only to the contractor, for the buildings and other work when built, completed, and accepted as herein specified. But if approved by the Chief of Ordnance, under paragraph 132, Ordnance Regulations of 1877, partial payments may be made from time to time during the progress of the work, provided the material furnished and the labor performed be perfectly satisfactory; provided further that no payment shall be made for more than 80 per cent of work done and material furnished at the time of payment, and it is to be understood that no certificate given, or payment made under this contract, except the final certificate, or final payment, shall be conclusive evidence of the performance of the contract. No responsibility of contractor for material, transportation, tools, or labor will be assumed by the United States.

Water.—The United States will furnish water and sand for building purposes and make the necessary connection with the present water supply.

Staking out.—The buildings will be staked out, the batter boards, guides, and stakes furnished and set by the contractor. The United States will do all excavating, refilling, and grading required for the buildings, or drainage, and all outside drains will be furnished and laid by the United States.

MASON'S WORK.

Cut stone.—Furnish and set cut stone for all exterior window and door caps and sills, the front and hatchway steps, the front steps with buttresses, the chimney caps, water table (except under the porches where it will be omitted, and two cast-iron lintels will support the brickwork). The water table will form the cellar window caps, being 8 by 14 inches high; elsewhere the water table to be 8 by 8 inches, with a 4-inch rounded wash; the cellar window sills, 5 by 11 inches; front gable sill, 5 by 7½ inches wide, elsewhere, 5 by 7 inches.

The chimney copings, cut with a rounded wash, are to be single stones 5 inches thick, the flue holes cut through. Doorsills about 8 by 18 inches; window caps, 4 by 13 inches. The keystones for windows in front gables to be of stone, as shown. All to be of the hardest grade of Longmeadow brownstone, fine crandalled on visible faces, except the hatchway steps, which will be coarse crandalled. The window sills will have lugs cut. All to be as per detail drawings furnished. Do all cutting, jointing, and fitting of stonework. All stone must be cut to conform to the lay of the bricks. Back joint the window caps 2 inches. In the frieze windows, furnish and bed in 1-inch thick sawed and rubbed black slate sills, 9 inches wide.

Brickwork.—No soft brick will be allowed to be used. All visible interior and exterior brick are to be hard-burned red brick, and all visible exterior work is to be laid up in bricks of an even shade of color and uniform size, from an approved shade selected by the commanding officer. The various thicknesses of walls is marked on the plans. The gable walls above the attic joist will be 9 inches thick. All bricks are to be well bedded in mortar, the joints flushed, laid plumb and true to a line, in close, even joints.

The mason will leave his staging and scaffolding in position for the use of the carpenters, slaters, and painters, and remove the same when the other mechanics are through with them. Keep the walls thoroughly braced and stayed during the progress of the work. Space under all window frames to avoid splitting courses of brick above or below the frame. Allow all braces, centers, and formers to remain in position until directed to remove them. All bricks are to be laid level, plumb, and true to a line, the joints thoroughly flushed with mortar. All bricks are to be slightly wet in dry weather and no bricks are to be laid in freezing weather. All inside partition walls where shown and colored red on plans are to be carried up the full thickness within 1 inch of the top of the joist. Leave 1-inch air space around all beam ends. Furnish and lay and build in all anchors, pipes, ducts, dampers, grounds, lookouts, etc., as specified or furnished by the heating or other contractors. Leave wall chases or other openings for the passage of all pipes where shown or directed. Build a foundation of brick for all outside stone steps. Do all cutting and patching in brickwork connected with the plumbing, wiring, gas-piping, heating, and ventilating, except the building of brick heating chambers, which will be done by the United States.

Strike the joints in all visible exterior and cellar interior brickwork with a steel.

All exterior brick walls are to be bonded with Morse's wall ties every seventh course on every brick. Lay the walls solid 4 inches around, below and above all openings. Keep the 1-inch air spaces clean as possible.

Wash down with water and diluted acid all visible exterior brick and stone work. Cover and protect all stonework, point up the same with a neat convex joint with slater's cement, colored red.

Mortar.—All mortar for stone and brick work is to be composed of freshly burned Follet's lime and fresh Rosedale cement in equal parts and a suitable proportion of clean, sharp sand. The lime mortar is to be slacked and stacked up at least five days, then tempered and the cement added as the mortar is mixed, and no cement mortar to be used after it has been allowed to set. All mortar for visible exterior work is to be colored red with Pecora or Ricketson's mortar stains.

Footings.—Footings for all walls and piers are to be of edger extra

hard-burned brick with 1½-inch offsets. See sections in basement plan; those not shown are to correspond with these.

Brick arches.—Where dotted lines show on the foundation plans across openings, turn segment arches, the radius the width of the brick opening, two 4-inch rowlock arches, the top course of rowlocks coming on a line with the underside of the floor timbers. Turn relieving arches over all interior openings that are 3 feet wide or more, and fill in with brick between the top of the lintels and the underside of the arch.

Check damp.—Just above the basement window sills in all exterior brickwork lay a check-damp course of Seyesel rock asphalt 16 inches wide, ⅛ inch thick (address E. H. Wooton, 502 East Twentieth street, New York), extending entirely through the walls of the building.

Cement plastering.—Below the finished grade plaster all exterior walls with Portland cement, mixed with an equal amount of clean, sharp sand, and applied ⅜ inch thick.

Fire stops.—Brick in on top of stud caps between the joists with bricks and mortar, filling the space to the underside of lining floors. Brick in on top of the roof plate up to roof boarding.

Molded brick.—Molded brick are designated by numbers on elevations from the Boston and Philadelphia Company's catalogue, No. 4, Liberty Square, Boston, Mass.

Wall chases.—Where shown on the plans and where directed, leave wall chases for the passage of plumbing and heating pipes, and plaster the same smoothly on the sides.

Ash pits.—In the cellar, where shown, build ash pits with cast-iron door and frame, door about 16 by 18 inches, set near the floor. Provide ash dumps under all grates of first story.

Range.—Build the jambs for the range as shown of red pressed brick, 5 feet 9 inches from the floor, lay ⅜-inch by 2-inch iron bars, start the flues for vent and smoke and plaster above, drawing the brickwork back 4 inches on front and ends.

Chimneys and flues.—They are to be built as shown on drawings, the joints well flushed with mortar, and the exterior of all flues and grate breasts and backs, inside of the building, are to be plastered before the furring or studding is set, from the underside of the first-story joist to the underside of the roof boarding. Keep all flues clean and test them, and see that they draw perfectly. Provide 6-inch stovepipe thimbles, with caps and brick around them, for kitchen and laundry. There will be an 8-inch wall around all exterior walls of chimneys above the roofs.

The grate flues will be 8 by 8 inches inside up to the top of the throats of the grates in the second story; above this they will all be 8 by 12 inches. Furnish and set in the vent flues in kitchen and laundry a 12 by 14-inch self-indicating vertical wheel register with tassel and chain.

Grates, tiles, and mantels will be furnished and set by the United States; but the contractor is to provide a 3-inch thick concrete bed for the tile and range hearths. Furnish and build in cast-iron fireplace dampers of proper size in the throats of all grates. Build the rough brickwork openings to suit the grates selected.

Concrete.—The United States will concrete the floor of the cellar.

Attic.—The contractors will include in their estimate the following work and materials: The entire exterior, roofs, floor timbers, bricking-in on top of the plate, collar beams, purlins, spruce lining floor, covering the entire story, windows and sashes, and the front and rear staircases, the stud walls and ceilings lathed and plastered—on the hall-

way side—and the necessary doors and windows cased and trimmed inclosing the same, and the rift North Carolina pine and finished floor in this portion, the tank, and all gas-piping. The portions which enter into the contract are colored solid yellow on the floor plans, being finished; that portion "hatched" being estimated separately, including the rift, North Carolina pine flooring in these portions, the doors and windows cased and trimmed and the lath and plastering of the walls and ceilings.

Lathing.—Lath all furred walls, stud and plank partitions, soffit of stairs and ceiling, unless otherwise specified, with sound spruce lath, with four nailings to each, except on the ceilings, which are to have five, and break joints every ninth course of lath. The lath are to be spaced a proper distance apart, as directed by the commanding officer. The lather is to test all furrings, corners, and angles, and notify the carpenter of all that are not firm and secure and have them made so before lathing.

Except the lathing and plastering over the indirect radiators, there will be no lathing or plastering in the basement, and only the stairway and hall, front and rear, of the attic, unless the contractor is employed to finish the entire story. Lath with hoops or wire lath all rounded corners.

Plastering.—The brick walls are to be furred and lathed and plastered as specified under furring, and all stud walls lathed and all plastered three good coats.

Throughout the first coat is to be a heavy coat of well-haired brown mortar. Thoroughly scratch-coat all ceilings and the soffits of stairs. The third or last coat is to be a dry-sand finish, troweled smoothly, using fine-washed and sifted river sand and lime putty, with a sufficient amount of plaster of Paris to enable it to be worked properly. The mortar for the brown coat is to be composed of well-burned lime thoroughly slacked and a proper amount of clean, sharp sand and long strong cattle or goat hair to make a strong mortar and stacked up seven days before tempering. Press the brown coat through the lath, giving a good clinch; straighten it with long straight edges and bring the mortar well up to grounds, and have all angles plumb and square. The lath and plastering is to be carried down to the floor and behind all baseboards and wainscot. Do all patching after other workmen, clean the mortar from the floors, sweep out the house, and leave all ready for finish. Guard against the rapid drying or freezing of mortar, and provide heavy cotton cloth on frames for temporary closing of openings.

CARPENTER WORK.

Framing stock, unless otherwise specified, is to be spruce, sound, straight-grained, and free from defects. All wood lintels, grounds, plates for partition studs are to be of dry stock, to avoid shrinkage. All studs are to be sized and set perfectly plumb and true. All timbers are to be framed, braced, bolted, pinned, and anchored in best manner, the joists tusk and tenoned and pinned into the girders. No wood work is to be placed within $\frac{1}{2}$ inch of the outside of any smoke flue. All joists, girders, and beams resting on brick or stone walls are to be leveled up with slate where necessary. Guard against injuring brick walls in setting the framing timber, and keep the walls where necessary well braced and protected during the progress of the work. Set plumb and true all frames and firmly stay them.

The sections, framing plans, and the notes and memoranda on them are to be followed as well as these specifications. Wrought-iron bolts and anchors are to be placed in position and secured to timbers in a substantial manner, the girders and joists dogged and spiked together at every opportunity, so as to prevent the possibility of spreading.

See the clause for ironwork for lintels, anchors, etc. Furnish the mason with grounds, lookouts, and wood blocks, and give directions for setting the same for securing the finish or other work that is necessary to be built in as the work progresses. Truss all partitions not having a solid support below and over all door and window openings in stud walls and partitions. Door studs are to be set double. All beams will bear 8 inches on the masonry walls and all joists 4 inches, and they are to be beveled off so that the tops of the beams will come on a line with the top of the brickwork above.

Partitions.—All stud partitions are to be capped with 2 by 4 inch studs, the studs and joists resting on the cap where partitions come over those below; the studs and joists are to be nailed to the capping and the studs and joists spiked to each other at every opportunity where they pass. Stud partitions over brick walls are to set upon 2 by 8 inch wall plates. Fill in with 4-inch brick filling to the top of floor.

Ironwork will consist of the following special items for each house and of the size and form given on details:

Cast-iron lintels:	
4 feet long	52
4 feet 6 inches long	16
6 feet long	1
7 feet long	2
5 feet 6 inches long	2
¾-inch bolts, 2 feet 6 inches long	22
½-inch bolts, 1 foot long	40
⅜ by 1¼ inch bolts, 3 feet long	49

Joist anchors, the ends split and turned each way 4 inches to both bolts and anchors, also all other bars, truss rods, dogs, bolts, spikes, nails, and screws that may be found necessary. Use only steel-cut nails and spikes for frame and rough boarding. Set wall plates and joist anchors for the mason to build in. Build wrought-iron porch rails as shown, the top and bottom rails ⅞ by ⅞ inch, the verticals ⅞ by ⅝-inch, the scrolls $\frac{3}{16}$ by ⅝ inch.

Bridging.—Studding to be 2 by 4 inches, 16 inches on centers; partition studs dividing the closets are to be set flat-wise. All studs in partitions are to be bridged with 2 by 4 inch stock, cut in herring bone flatwise and well nailed, and all joists in floors and ceilings over 12 feet long are to be X-bridged with 1¼ by 2 inch stock. Where a partition is intended to rest upon another below it must stand on the partition cap and not on the floor on top of the joist.

Centers.—Furnish the mason with centers and formers for all arches and set the same, and all window and door frames and other materials designed to be built in the masonry as the work progresses, without delaying the mason work.

Lintels.—All lintels over interior brick openings above the basement are to be of old dry stock, not less than 3 inches thick. All lintels in exterior brick walls will be cast iron, as elsewhere specified.

Roof.—Construct the roof as shown on the framing plans and sections.

Cutting.—Do all cutting and framing for heating contractor, plumber, gas-fitter, bell-hanger, and electric work, and make such provision for these wires, pipes, and registers as may be required.

Furring.—Cross-fur first, second, and attic story ceilings with 1 by 2 inch furring strips, placed 12 inches on centers, well nailed for receiving the lath. For all exterior walls indicated on the plans as furred with $1\frac{1}{8}$ by 3 inch strips, 16 inches on centers. Fur around all chimneys with 2 by 4 inch studs set flatwise.

Grounds.—Around all openings, under baseboards and wherever necessary to provide a good nailing for finish, place $\frac{7}{8}$ by $\frac{7}{8}$ inch dry pine grounds, well nailed and secured.

Lining floors.—In the first, second, and third floors lay $\frac{7}{8}$-inch matched spruce lining floors, *laid diagonally*, and well nailed to each bearing, the boards being cut so as to bear the whole length across each timber, and at the ends 2 by 4 inch strips between the joists are to be cut in to receive the ends of the boards.

Roof boarding.—All roofs are to be boarded with matched $1\frac{1}{8}$-inch seasoned spruce boards, not over 8 inches wide, laid close and well nailed three times to each bearing,

Slating.—Cover all steep roofs with the best quality of Brownville, Me., black slate of an even color and thickness, size 10 by 16 inches, laid with 2-inch head lap, except slate for hips and porches, which are to be of proper size, all nailed with galvanized-iron nails. Previous to laying the slate cover the roof boarding with heavy tarred paper. Bed the slate at the eaves and on hips in slater's cement. Repair all broken slate and warrant the roof not to leak for one year. Folsom's, or equivalent, galvanized-iron snow guards are to be laid in each alternate slate on the entire side of roof coming over porches.

Sheet-metal work.—Form open valley in the slate roofs and line the same with 16-ounce copper 16 inches wide. Form gutters in all level wood cornices as per detail drawings, with a gradual slope to the leaders; line the same with 16-ounce copper. Form a ridge roll 1 inch radius, 6 inches on each side of ridges, well secured; also hip rolls similar on all porch hips, and flash with copper all exposed places, and cap flash with 4-pound sheet lead cut in the brickwork.

Furnish and put on 3 by $3\frac{1}{2}$ inches square, finely crimped, No. 26 galvanized iron conductors, with all necessary curves and bends, and wire basket soldered at the mouth, firmly secured to the brickwork, and connecting to the outside drains; for the position of leaders see the plans and detail of cornice. Extend the gutter lining 4 inches up under the slate; turn down and thoroughly and neatly nail same to the outer edge of wood cornice.

Hot-air pipes.—Where shown on plans furnish and put in IX bright tin warm-air pipes for indirect steam heating; also make tin register boxes, and set same with preparations for registers. Clean out same and leave ready for connection. The exact position, sizes, and shapes of these pipes and register boxes will be determined by the commanding officer. Registers will be furnished and set by the United States.

Frames.—Build basement and single casement window frames of $1\frac{3}{4}$-inch thick pine plank, rebated $\frac{1}{2}$ inch by $1\frac{3}{4}$ inches for sashes. All double casement frames are to be made of $\frac{7}{8}$-inch stock, except the sills and heads, which will be $1\frac{3}{4}$-inch, and provided with long pockets to receive the weights. The pulley stiles, with the parting strips, are to be Georgia pine. Door frames that are built in the brickwork are also to be of $1\frac{3}{4}$-inch stock, anchored into the brickwork twice on each side, and doweled into stone sills, with iron anchors and dowels. The frames on the first stair landing are to have a loose head and follower. The above frames are to be primed and dried all over before delivery at the building (except the pulley stiles, which are to be oiled), and made of well-

seasoned dry stock. Double casement frames are to be provided with $2\frac{1}{2}$-inch steel axle pulleys, grooved for ribands. All are to be made as per detail drawings furnished. All sashes are to be hung with cast-iron weights, exactly balancing the sashes, and Gardner's steel ribands over square grooved pulleys.

Sashes.—All sashes are to be of kiln-dried, first-quality clear Michigan pine, $1\frac{3}{4}$ inches thick, acorn lip sash of the sizes marked on the elevations.

The windows for front and rear parlors, dining room, first-story hall, and first landing are to be glazed with first-quality plate glass; all other sashes are to be glazed with the best quality of American double-thick sheet glass; all to be bradded, putty set, and back puttied. All single casement basement sashes are to be hinged at the top with 4 by 4 inch wrought butts and provided with heavy bolts. All sashes are to be primed before delivery. Furnish, fit, and trim around a ground-glass sash, 6 feet above the floor, 2 feet high, 3 feet wide, made stationary, for lighting closets in the first and second stories.

Slide.—Make $1\frac{1}{8}$-inch thick weighted, paneled slide between pantry and kitchen, where shown.

Outside finish.—All outside finish is to be of thoroughly seasoned, sound, clear, $\frac{7}{8}$-inch and $1\frac{1}{8}$-inch thick, second-quality pine, worked and molded as per detail drawings. All is to be primed as soon as possible.

Porches.—Porches are to be built as shown on the details. The porch floors one thickness of dry $1\frac{1}{8}$-inch matched rift North Carolina pine flooring, 3 inch face, all laid close, and well nailed. The front turned columns are to be of white pine, bored through in the center vertically, with 1-inch holes; they are to be turned with the entasis, as shown on the detail, and have carved capitals, as per detail drawings. Outside steps to rear porch are to be of North Carolina pine, $\frac{7}{8}$-inch stock, supported upon three 2 by 10 inch carriages. Sheath the under side of all porches with $\frac{1}{2}$-inch thick North Carolina pine, matched and beaded sheathing, with a neat $1\frac{3}{4}$ by 2 inch molding around angles, thoroughly nailed, and kept clean for natural-wood finish. Build screens under the porches of $\frac{7}{8}$-inch stock. Put on E. H. Purdy's ornament, No. $2239\frac{1}{2}$, formed into a garland in front porch gable. Address 42–48, West Thirteenth street, New York.

Blinds.—Furnish, fit, trim, and hang outside blinds to all windows above the basement; they are to be $1\frac{1}{4}$ inches thick, rolling slats, of dry white pine, and provided with Lull & Porter's gravity fixtures.

Hatchway.—Build the hatchway as shown, and fit, trim, and hang $\frac{7}{8}$-inch matched pine double doors, the 2-inch plank coping being anchored to the brick walls.

Inside finish.—The detail drawings show the general design and construction of all inside wood finish; all is to be of sound, seasoned, clear, first-quality, kiln-dried stock, and, unless otherwise specified, will be of white wood for natural finish or staining.

All is to be smoothly sandpapered with the grain of the wood. None of the finish is to be put up until the plastering is thoroughly dry, and is to be well nailed to grounds. All rooms, unless otherwise specified, are to be cased and trimmed in a manner corresponding to those shown. The entire first floor, except the kitchen, pantry, and laundry, will be finished in first quality Canada brown ash, and the main and rear staircases and landings, including the staircases to the attic.

Base.—Base in all principal rooms, and unless otherwise specified,

will be 11 inches wide, the top molded; in the closets, 6 inches high, beveled.

Trim.—Trim for all principal rooms to be as per detail; in pantry and servants' room and rear halls to be $\frac{7}{8}$ by 5 inches, plain casing, all with $1\frac{1}{8}$-inch molded corner blocks, and door casings are to have $1\frac{1}{8}$-inch thick, 10-inch high beveled plinth blocks, except in closets and pantries, where the casings will run to floor.

Door frames.—All door frames, except where otherwise specified, above the basement are to be of $1\frac{3}{8}$-inch stock, the wood corresponding to the finish of rooms, except the front door frame, which is to be, as per detail, of ash.

Stop casings.—Set $\frac{1}{2}$-inch thick stop casings for all windows and doors, molded as shown; those for the windows are to be screwed on, with blued screws, about 12 inches apart; those on the door frames, nailed on. The top stop for the window frames is to extend to the top sashes.

Sliding doors.—Stud with 2 by 4 inch studs, set flatwise, 12 inches on centers, and sheath horizontally with dry $\frac{7}{8}$-inch matched pine sheathing, and close the ends of the pockets tightly. The contractor will also furnish and put up Coburn's patent sliding-door tracks and hangers, carefully adjusting the same to the doors.

Doors.—All doors are to be of the size and thickness marked on the plans, and of the style and finish shown on detail drawings, all to be blind tenoned, and sandpapered with the grain of the wood. Doors opening into rooms or halls having stained or natural wood finish are to be veneered with wood of the same kind as the finish, except white wood doors, which are to be solid, the veneer $\frac{1}{4}$-inch thick, upon kiln-dried white pine cores. The front outside door is to be veneered with ash on both sides.

The doors that are not shown in detail are to be common pine, sunk four paneled, flush o. g. molded doors. The outside front door is to be glazed, in the upper panels, with beveled plate glass. The transoms glazed with plate glass over the front door. All are to be fitted, trimmed, and hung in the best possible manner. Put rubber-tipped door-strikers behind all doors that swing.

Thresholds.—Thresholds are to be placed, $\frac{1}{2}$-inch thick of cherry, as wide as the jamb, in all inside door openings. Omit thresholds where directed.

Staircase.—The main stairs are fully shown on the detail drawings; the same to be executed *throughout* in thoroughly kiln-dried, first-quality brown ash, except the treads, which are to be of oak; also the floors of the landings. House the ends of the treads into the wall string, firmly bolt and secure the newels, and draw the rails into posts with draw-bolts.

The stairs are to be firmly supported upon three 2-inch thick thoroughly seasoned pine carriages. Rear stairs are to be of $\frac{7}{8}$-inch brown ash stock, with $2\frac{1}{4}$ by 4 inch molded ash hand rail, $1\frac{1}{4}$-inch turned balusters, two on a tread, newel posts 4 by 4 inches, with turned caps. The treads and risers also housed into wall string, the treads of maple or birch, two 2 by 10 inch carriages supporting the $\frac{7}{8}$-inch treads and risers; all strong and secure. The stair landings are to be supported with 3 by 4 inch supports, 12 inches on centers, covered with lining and finished floors, and lathed and plastered underneath.

Wainscot.—Wainscot the rear halls and stairways, kitchen, laundry, bath and toilet rooms with $\frac{1}{2}$-inch matched and alternate boards molded, *3 feet 6 inches* high, except back and around ends of the plumbing

fixtures, where the wainscot is to be 6 feet high; this wainscot will have a base 11 inches high and 5 inches wide, capping rebated, and the wainscot dadoed off ½ inch to the depth of the molding.

Casings and plumbing woodwork.—Case up all soil pipes with screws, so that the casings may be easily removable. Provide the plumber with the necessary neatly finished strip for securing pipes. Cut in blocks and grounds for securing brackets or fixtures. Furnish material for and build cabinets of white wood under the washbowls, with four small drawers at one side and a small dwarf paneled door. Case up the bath tubs with sunk panel casings. Make 1⅛ by 4 inch rounded cherry rims for the tubs. Set cabinet made water-closet seats and lids of 1⅛-inch thick oak, with rubber buffers and plated butts.

Arches.—Where indicated by dotted lines on floor plans, fur down elliptical arches, as per detail, and lath and plaster the same, with a plaster quirk on the outer edges; the soffit to be 7 inches wide.

Quirks.—Put on dry white pine quirks before lathing, well nailed, on all exposed places.

Skylight.—Build two skylights in the roof, as shown; glaze the same with ¼-inch thick hammered plate glass. If the attic is finished off, sheath and case around the same.

Floors.—Repair all lining floors and make solid all nailings. Overlay all lining floors with 16 ounce to the yard Warren Ehret Company (No. 428 Market street, Philadelphia, Pa.) No. 11 deadening felt. Turn a strip, 6 inches wide, 3 inches up under all baseboards. The upper or finished floors in vestibule, front and rear parlors, passage, dining room and staircase hall, bath and toilet rooms, in second story, are to be of ⅞-inch first-quality birch or maple, kiln-dried, matched flooring, 2½-inch face. The other floors in first story, and floors in closets, first and second stories, and halls and passages, second story, and the finished portions of attic are to be kiln dried, matched, 3-inch face, rift North Carolina pine flooring. All other floors are to be dry, matched, 5 inches wide, second quality white pine flooring. All floors are to be cut in between baseboards, thoroughly blind nailed to each joist or bearing. Where directed by the commanding officer, put down the lining and finished floors with screws, that any plumbing pipes or traps may be easily reached. Miter a 4-inch-wide cherry border around the hearths, first story, and also around the walls of all rooms, halls, and vestibules having maple or birch floors.

Closets, etc.—The United States will furnish labor and materials, and do all fitting of shelves, cupboards, closets, cleats, drawers, lockers, etc., but the contractor is to place the necessary grounds, case and trim all openings, furnish and hang the doors leading to these rooms, etc.

Painting.—All exterior painting, except the priming as elsewhere specified, and all interior painting and finishing of woodwork will be done by the United States.

Hardware.—All finishing hardware. such as sash locks and lifts, door trimmings, and not otherwise specified, will be furnished by the United States, but the contractor is to make a complete list and fit and apply the same.

Bells and speaking tubes.—Furnish and put up in complete working order a self-indicating, wire-call annunciator and electric bells, connecting with No. 16 water-proof B. B. wire, with push buttons as follows: To each of the three principal chambers, and hall in second story, and hall in attic, and first story, with a floor call from the dining room, and the front and rear entrances. These wires are to be concealed and securely fastened to the sides of studs or furrings, and not in the

plastering. The push buttons are to be square, brass or bronze, polished. The annunciator in an oak case.

Put up 1-inch speaking tubes, also concealed, from the main second-story hall to the kitchen, to have self-indicating whistles, porcelain mouthpieces.

Gas piping.—Pipe the house for gas in accordance with the gas company's regulations; test the same before lathing and after plastering. The position of outlets is marked on the plans. Consult with the commanding officer and make any changes in the position which he may desire. All fittings for gas pipes are to be of galvanized iron. Pipes on the ceilings are to run in between the joists or furring strips.

Tank.—Build a tank in the attic, 4 feet by 2 feet 6 inches by 3 feet wide, of $1\frac{3}{4}$-inch plank, braced, bolted, and yoked together in the strongest possible manner, supported on 6 inch by 6 inch sleepers. This tank is to be lined with 16-ounce tinned copper by the plumber.

Plumbing (see General Conditions).—These specifications and the accompanying drawings are intended to embrace all of the labor and materials necessary for the plumbing of the entire building, the whole to be comprised within any contract that may be made for the same. The entire work is to be done and finished in every part in a good, substantial, and workmanlike manner, according to the accompanying drawings and these specifications, and the full intent and meaning of the same, and to the entire satisfaction, approval, and acceptance of the commanding officer. The plumber will give his personal superintendence to the work, and the commanding officer is to have access to the work at all times. He may require the dismissal of any incompetent or careless workman, or the removal from the premises of any material not in accordance with these specifications, at the expense of the plumber.

The plumber will furnish all the implements, cartage, and transportation of all kinds, including any material or labor not specially mentioned, but which is necessary for the proper carrying out of the specifications, except the marble-work, cocks, lead traps, lead water-closet bends, water-closet cisterns, and all plumbing fixtures, which will be furnished and delivered by the United States.

All the materials are to be new and first class in every respect unless otherwise specified. There must be no change in them without the approval of the commanding officer.

Should the specifications vary from or conflict with the drawings, the plumber is to be governed by the specifications. He is to carry forward his work at all times with the greatest reasonable rapidity. During construction all pipe ends must be covered to prevent the entrance of any substance that would cause an obstruction. No hooks to be used in fastening lead pipes.

Hot and cold water pipes to be kept at least 1 inch apart everywhere. All stopcocks, traps, and supply pipes to be easy of access.

No cock or supply pipes to be placed at the end of a line of pipe. Leave an air chamber of at least 12 inches where possible. Avoid the unnecessary cutting of timbers for pipes, and any that is necessary is to be done by the carpenter. Make connections with the tile drains as laid by the United States. The carpenter is to put up neat $\frac{7}{8}$-inch wood strips of proper width, upon which will run all water and service pipes, so that they can be easily reached for examination or repair at any time. No pipes will be allowed to run on the outside walls of the building unless absolutely necessary. All pipes in exposed places that

will be filled with water liable to freeze must be packed with mineral wool, properly boxed. Avoid dips or short bends in all lead pipes.

No pipe or fitting shall be covered from view until it is passed upon by the commanding officer. After completion of the piping, and before any fixtures are connected, all openings of waste, soil, and vent pipes are to be plugged and the whole system of pipes filled with water and allowed to stand twenty-four hours. If any leak is shown the test is to be repeated until the entire system is proved gas and water tight.

Grade of pipes.—Water pipes, in every case, must have a gradual fall from the fixture which they supply, and cocks so placed that every pipe can be entirely emptied of water. The horizontal waste pipes must be given all the fall possible.

Cast-iron pipe.—All cast-iron pipe, including both waste and air pipes, are to be sound and free from flaws, all to be put up in the strongest manner, with iron hooks and stays, with all proper and necessary fittings.

All the above are to be Mott's, or equivalent, extra heavy bituminized soil pipe, of the following weights per foot, each length of pipe and fitting bearing their mark cast in raised letters:

	Pounds per foot.
2-inch	5½
3-inch	9½
4-inch	13
5-inch	17
6-inch	20
7-inch	27
8-inch	33½

The soil pipes in the attic are to increase from 4 to 5 inches above the ceiling of the second story, through Mott's increasers, and thence 3 feet 6 inches above the roof. Where the soil pipes pass through the roofs, flash with 16-ounce copper, 18 inches square, with a funnel around the pipe, the flashing secured to roof, and the funnel turned over and calked into hub of pipe, all water-tight. Place a strong wire basket, well secured, at the mouth of pipes above the roof.

Hand holes.—In the cellar, in the most accessible position, provide suitable fittings for hand holes, and calk in a brass screw ferrule with a brass screw. The soil pipes will be carried along the ceiling of the cellar and drop down to enter the outside drains at a proper point.

Vent of traps.—All traps, except water-closets, are to be ventilated at their outlet through 1¼-inch 2½-pound lead pipe, and the water-closet traps to 2-inch 4-pound, leading to 2-inch cast-iron pipe, making direct connection with the nearest soil pipe above the water-closets through an inverted Y. The joints are to be calked with oakum and molten lead in the same manner as in soil pipes.

If it is not practicable to carry the 2-inch vent pipe to soil pipe, then the same must run independently through the roof and be protected in the same manner as the larger pipe. All trap vent pipes are to be run with a continuous upward slope.

Joints.—All joints between cast-iron pipe must be thoroughly calked with oakum and molten lead, entirely filling the hub. All joints between cast-iron and lead pipe must be made by heavy brass ferrules, of the same size as the lead pipe, soldered on the lead pipe and calked into the iron pipe.

Lead pipes.—All vertical lead pipes to be supported by hard metal tacks, soldered to the pipe and fastened with brass screws and strips; tacks not to be more than 2 feet 4 inches apart. All horizontal pipes must be supported throughout their length on boards or shelves, to

prevent their sagging, and supported every 1 foot 6 inches in the same manner. *Hot-water pipes* must *not* be fastened with tacks; brass bands only are to be used, placed 8 inches apart to allow for expansion and contraction. Weight of lead pipe, unless otherwise specified, is to be as follows:

	Pounds per foot.
Supply pipes, ½ inch, A. A	2
Supply pipes, ⅝ inch, A. A	2¾
Supply pipes, ¾ inch, A. A	3½
Waste pipes, 1¼ inches	2½
Waste pipes, 1½ inches	3½
Waste pipes, 2 inches	4

Water supply.—Start from a point inside the cellar wall, on the east side, just under the butler's pantry, to which point the water supply is to be carried by the United States; attach a 1-inch stop and waste cock, and run a 1-inch lead-lined wrought iron pipe, to supply the principal tank in the attic. Branch from this pipe with lead pipe to slop, kitchen, and pantry sinks, and two washbowls. Temporary water supply, for building purposes, will be furnished by the United States.

Tank in attic will be furnished by carpenter, of the following size: 4 feet by 2 feet 6 inches by 3 feet, inside dimensions, and is to be lined with 14-ounce tinned copper, by the plumber. Supply this tank from rising main, as described above, through a ⅝-inch compression ball cock, Mott's make, 8-inch copper ball, and furnished with 1½-inch pipe, arranged with 1½-inch plug and chain, to be removed for cleaning out tank, and connect with soil pipe. Provide a 1¼-inch standing overflow pipe, and discharge into water-closet tank in servant's room, or the slop hopper. From this tank, through ¾-inch 3½-pound pipe, run supply to water-closet cisterns, laundry tubs, boiler and bath tubs, and all other fixtures not supplied from the rising main. Place a shut-off cock on this pipe, to shut off water from house when necessary. Beside the tank, arrange with a short pipe and two stop cocks, so that the supply to the tank can be turned into the ¾-inch lead pipe from the tank.

Range boiler.—Set one 80-gallon copper range boiler, with ground couplings, for hot and cold water, on Lockwood's plain cast-iron boiler stand; connect with brass coupling, and branch from the ¾-inch supply from tank, through ⅝-inch, 2¾-pound pipe, with stop cock, the pipe passing through the top, and discharging within 10 inches of the bottom of the inside of boiler. Place ¾-inch plug sediment cock at the bottom of the boiler, this cock to have hose screw for emptying boiler.

Expansion pipe.—Run a line of ½-inch 12-pound pipe from the highest point in hot-water pipe from the boiler to a point just over main tank, and bend same over tank.

Wash trays.—Set where shown in laundry three soap-stone wash trays, and supply each with hot and cold water *through the back.* Tubs to be firmly supported upon galvanized iron legs. They are to be placed 6 inches away from the wall. The hot and cold water supply to be through ¾-inch 3½-pound lead pipe, with ⅝-inch brass compression, as per Fig. 337, Colwell Lead Company's catalogue, 1¼-inch brass plugs and chains, and the necessary length of 1½-inch lead pipe, 3½ pounds to the foot, furnished with 4-inch dome lead trap and brass trap screw, and connected to the soil pipe through the proper Y branch, and 2-inch pipe.

Kitchen sink.—Set where shown on plan one 42 by 22 by 7 inches, Mott's 531 G, Demarest kitchen sink, galvanized, with back and legs as shown on plate in catalogue, all firm and secure. Supply with

⅝-inch hot and ¾-inch cold water lead pipe, and polished flange, and thimble bibb cocks. Cold-water cock to have hose screw for filter. Waste to be through strainer in center of end of the sink, 1½-inch, 3½-pound pipe, with 4-inch dome lead trap, and brass trap screw.

Butler's sink.—Set in butler's pantry one overflow butler's sink, of Mott's second quality, 521 G, 23 by 16 by 6 inches. Imperial pantry sink supplied with hot and cold water, through ⅝-inch lead pipe, ½-inch pantry cocks for hot and cold water; cold water from the main supply pipe. The sink to be provided with the accompanying nickel-plated sink plug and chain and chain stay. Waste pipe to be 1½-inch 3½-pound pipe, running to a line of 2-inch cast-iron pipe, connecting with nearest soil pipe, through Y branch. The waste pipe will be provided with 4-inch dome, lead trap, and brass trap screw.

Bath tubs.—In each of the bathrooms set one stamped and guaranteed 18-ounce, 5 feet 6 inches, planished copper overflow French shape bath tub, supplied with hot and cold water, by ⅝-inch 2-pound lead pipe, through separate nickel-plated ¾-inch compression double bath cocks, nickel-plated as per No. 5, Fig. 281, Colwell Lead Company's catalogue, and to waste through plated socket and strainer, with plated plug, chain, and chain stay, with 1½-inch 3½-pound lead pipe, to Y branch in soil pipe, passing through 4-inch dome lead trap, with brass trap screw, 1¼-inch overflow, branched into waste.

Washbowls.—Where shown on plans, place 16-inch round marbleized porcelain washbowls, unique waste, as shown on plate 401 G, 30 by 22 inches, set in 1¼-inch thick, countersunk, polished, best Italian marble, exposed edges. o. g. molded, and corners rounded, with sides and backs 10 inches high, ⅞-inch thick, o. g. molded, each bowl supplied with hot water through ⅝-inch and cold water through ½-inch 2 pound lead pipe, except the bowl in servant's bathroom, which will draw from the tank through ⅝-inch pipe, with nickel-plated compression cocks similar to Mott's 857 G. Bowls to be fastened to slab by three brass basin clamps. They are to waste through 1½-inch 3-pound lead pipe, 1½-inch lead S trap, with screw, into 1½-inch 3½-pound lead pipe, thence through Y branch to soil pipe.

Slop sink.—Set up, where shown, on second floor Mott's No. 2, 497 G sink, furnished with frame and legs similar to 489 G, with brass coupling instead of trap standard, with 3-inch running enameled iron trap and screw. The back to be galvanized iron, with air chambers, the sink porcelain lined. Supply with hot and cold water, through ⅝-inch lead pipe, and waste through 2-inch lead pipe into soil pipe.

Water-closets.—Except in servants' water-closets, place in each bathroom, where shown, Mott's embossed Inodora G 103 closets, supplied from 21½ copper lined tank, cabinet finished in ash, design B, polished brass, curved trap vent, polished brass brackets, for seats and cisterns, pull and chain on side near the wall. These closets are to rest upon countersunk polished Italian marble floor slabs, 1¼-inch thick, back and sides ⅞ by 8 inches high, beveled edges, plated, brass floor flange and nuts, connected to 4-inch lead bend, calked into branch of soil pipe.

The servants' water-closet is to be a No. 1 back outlet washout water-closet, of approved shape and make, with accompanying copper-lined cistern, cabinet finished, slow-closing valve, 1¼-inch 3-pound lead flush pipe, 2-inch lead trap vent, brass floor flange and screws, 4-inch lead bend. The seats and cistern to be supported on japanned-iron brackets. The brackets for the other closets to be brass, polished; all brackets being furnished by the United States. Each water-closet is to have a 2-inch seat vent, of spiral galvanized iron pipe, concealed in the par-

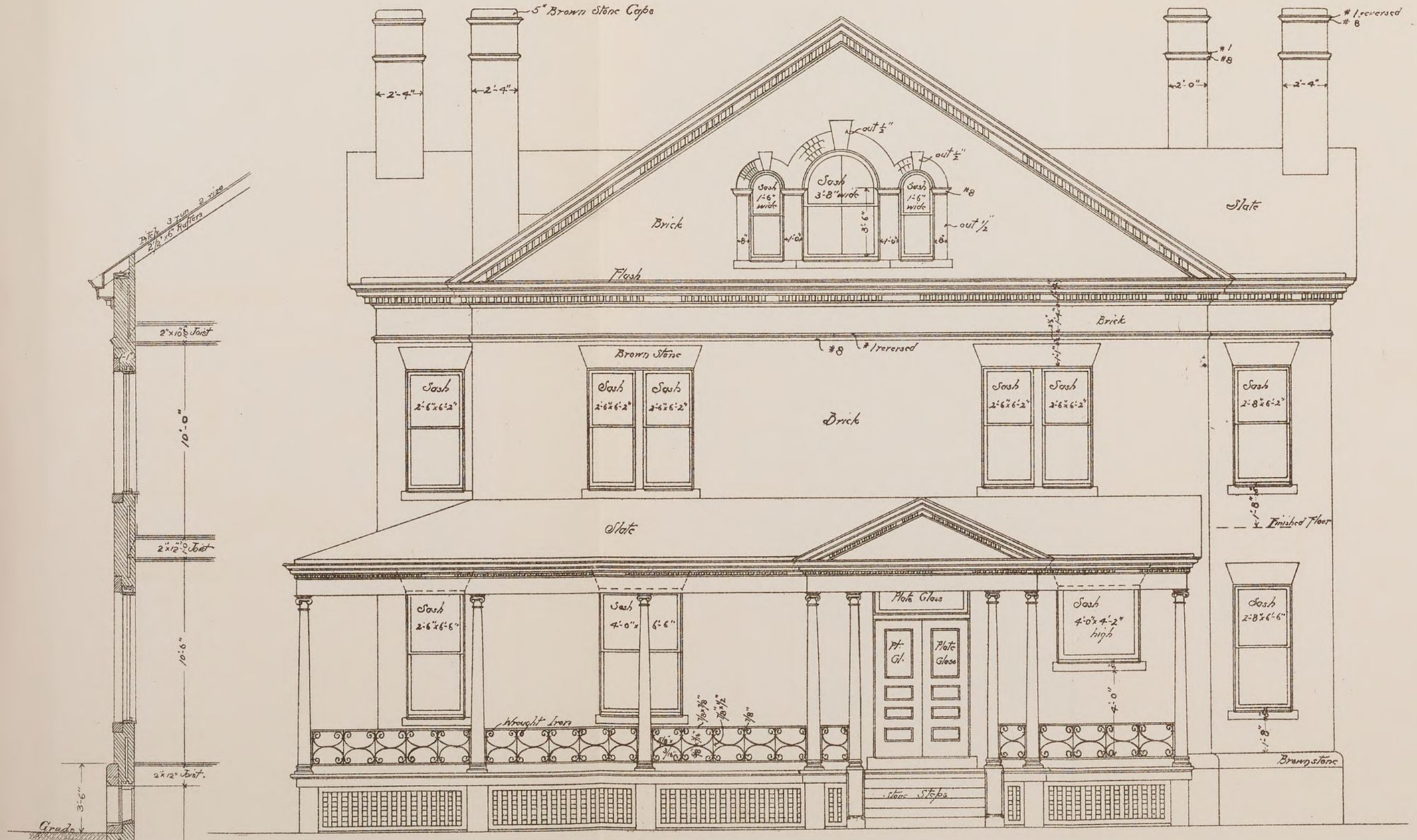
tition, passing upward, and near the roof connected to a 4-inch, thence to the kitchen range flue, firmly secured; also nickel plated pulls and chains. Each water-closet cistern is to be supplied from the $\frac{3}{4}$-inch pipe leading from the attic tank, through a $\frac{5}{8}$-inch branch.

Test.—As soon as the fixtures are all on, and the water let into the pipes, the traps are to be filled with water, and the whole system tested by closing all air pipes and other outlets, and pouring 2 ounces of oil of peppermint into the top of each soil pipe, followed by 2 gallons of thoroughly hot water, in the presence of the commanding officer, and if any odor of the peppermint is detected in any part of the house, the plumber, at his own expense, is to remedy such defects as allowed the vapor of peppermint to escape, and make the same good. This test is to be repeated until the whole is satisfactorily proven to be tight and perfect. The whole cost of making such test, and of removing and replacing other work disturbed to obtain access to pipes or fittings, and all expense of making good any damage, or replacing of any work, caused to any trade or other workman, is to be paid by the plumber. Each line of pipe is to be tested separately.

A. MORDECAI,
Colonel, Ord. Dept., U. S. Army, Commanding.

SPRINGFIELD ARMORY, *March 29, 1893.*

(1279–'93.)



SECTION THRO WALL

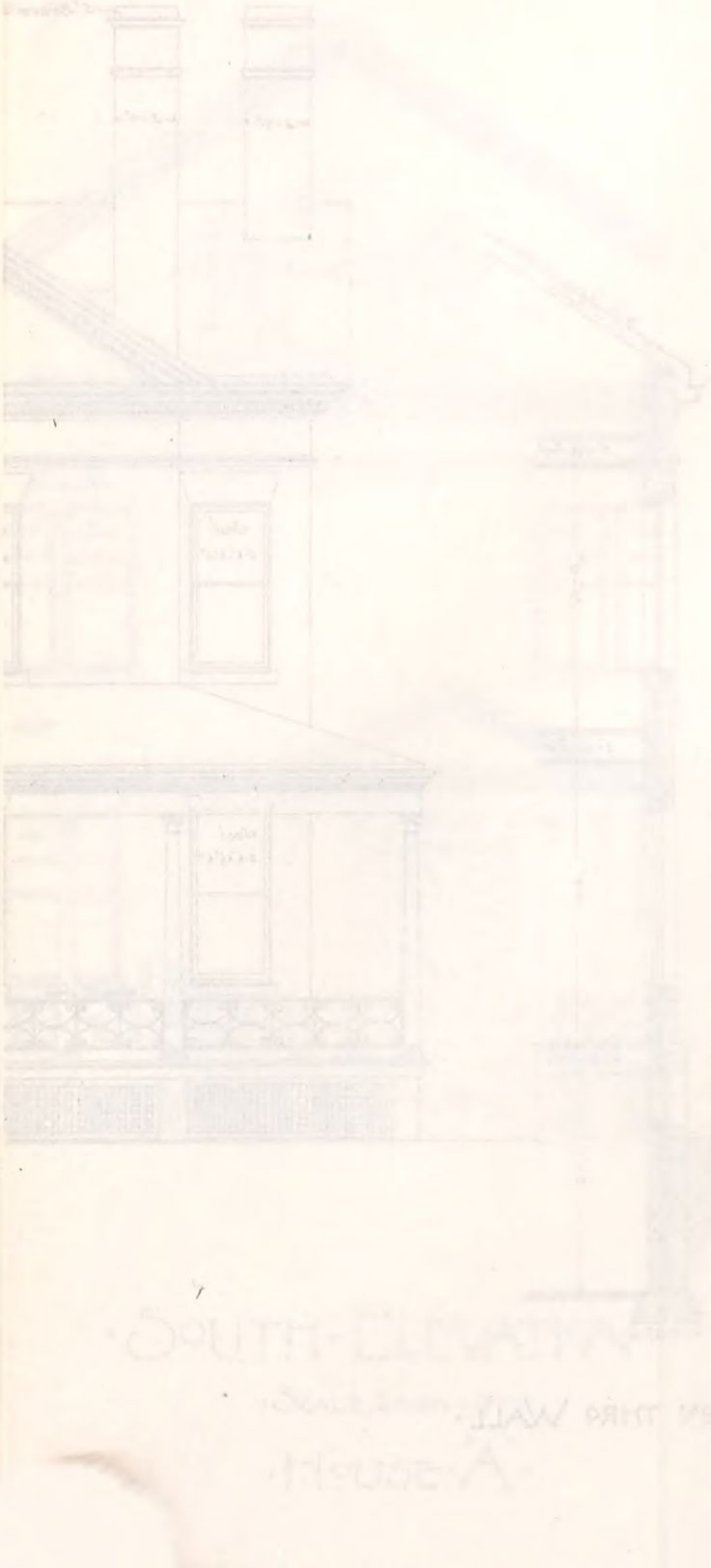
Ord 53 2

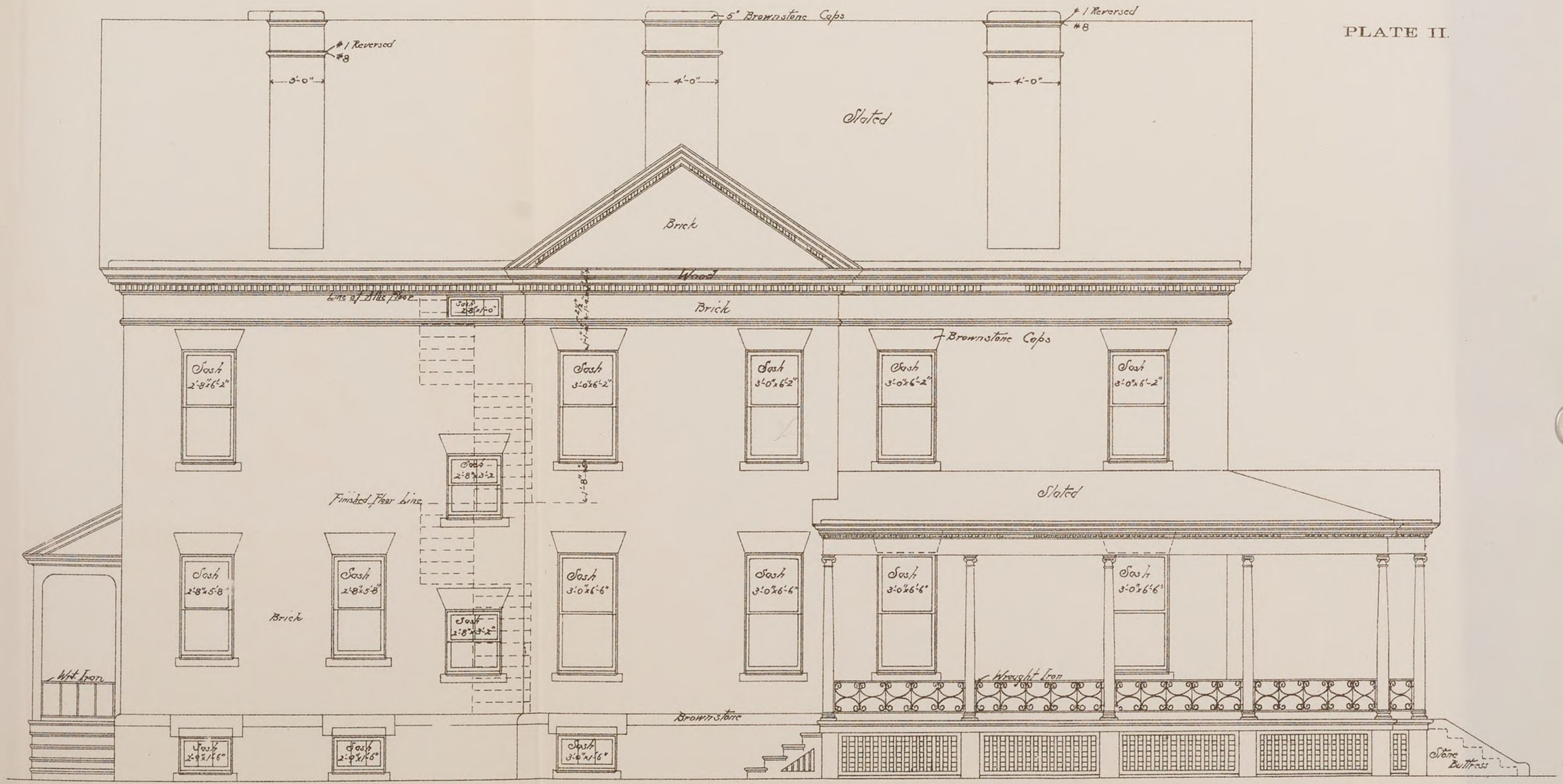
SOUTH ELEVATION

SCALE ¼ INCH = 1 FOOT

HOUSE "A"

Appendix 12, 1893.





WEST ELEVATION

SCALE 1/4 INCH = 1 FOOT

HOUSE "A"

Ord 53 2

Appendix 12 1893.

PLATE III.

· NORTH · ELEVATION ·

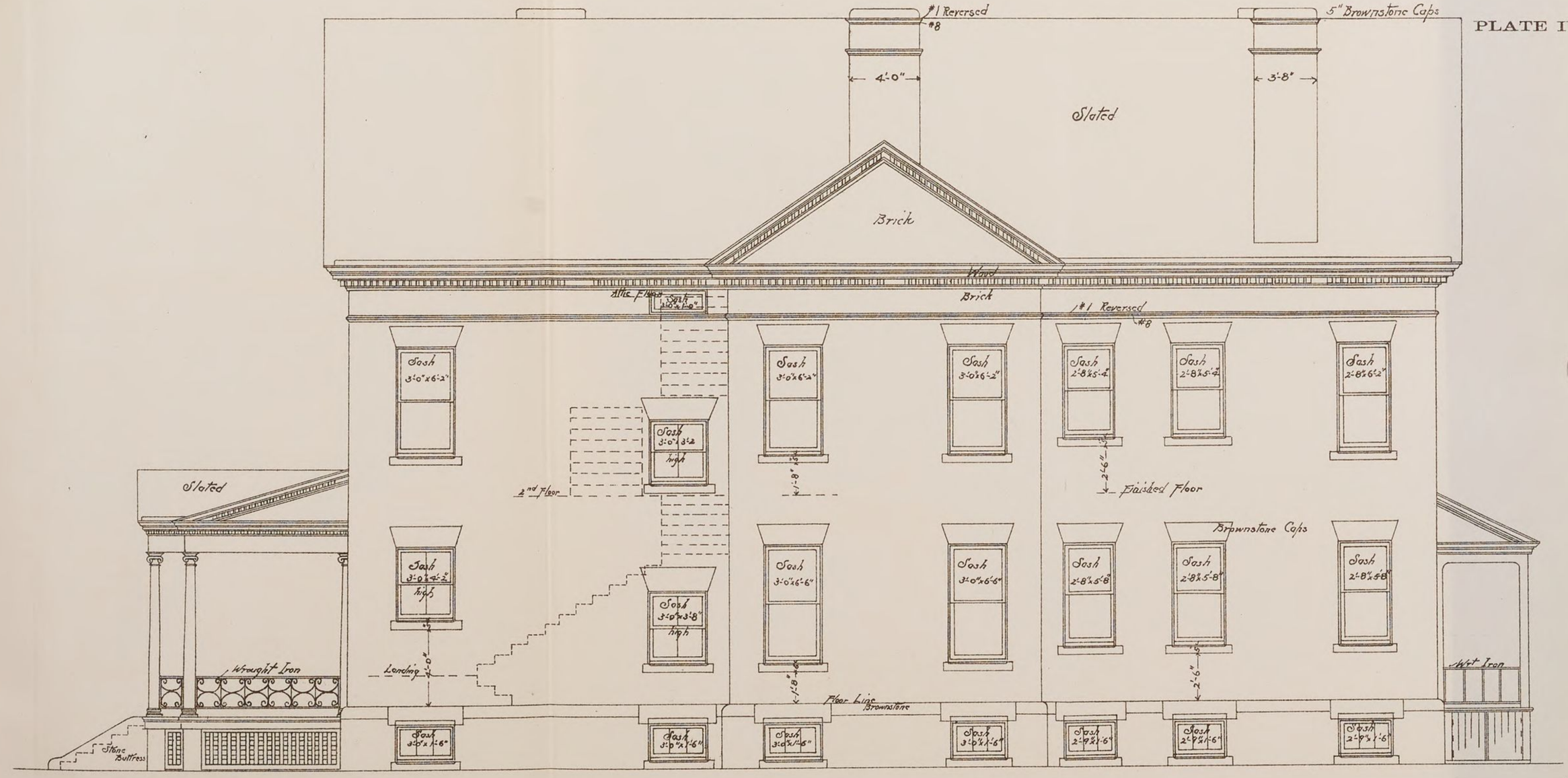
SCALE 1/4 INCH = 1 FOOT.

· HOUSE · A ·

Ord 53 2

Appendix 12 1893.

PLATE IV.



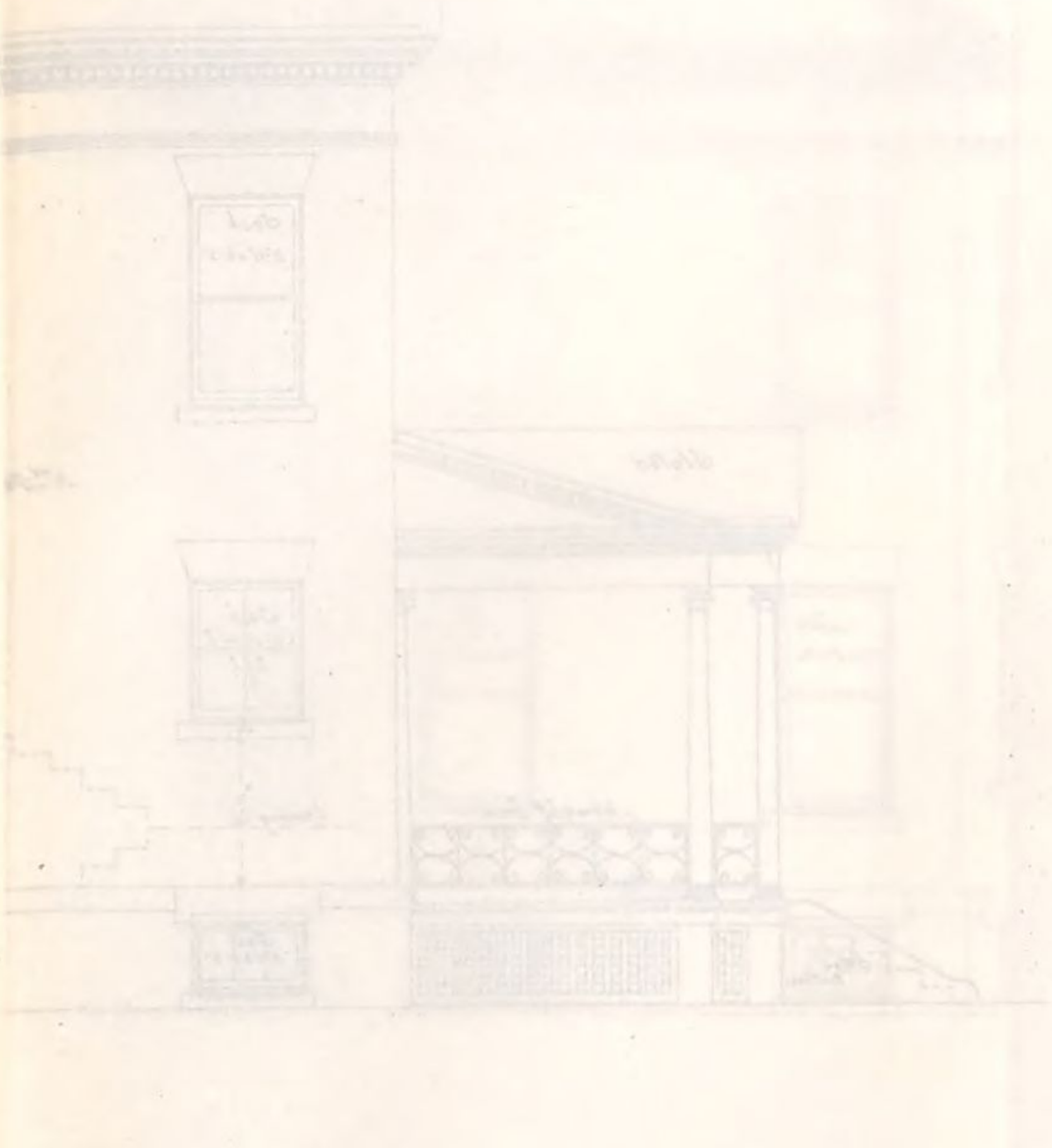
EAST ELEVATION

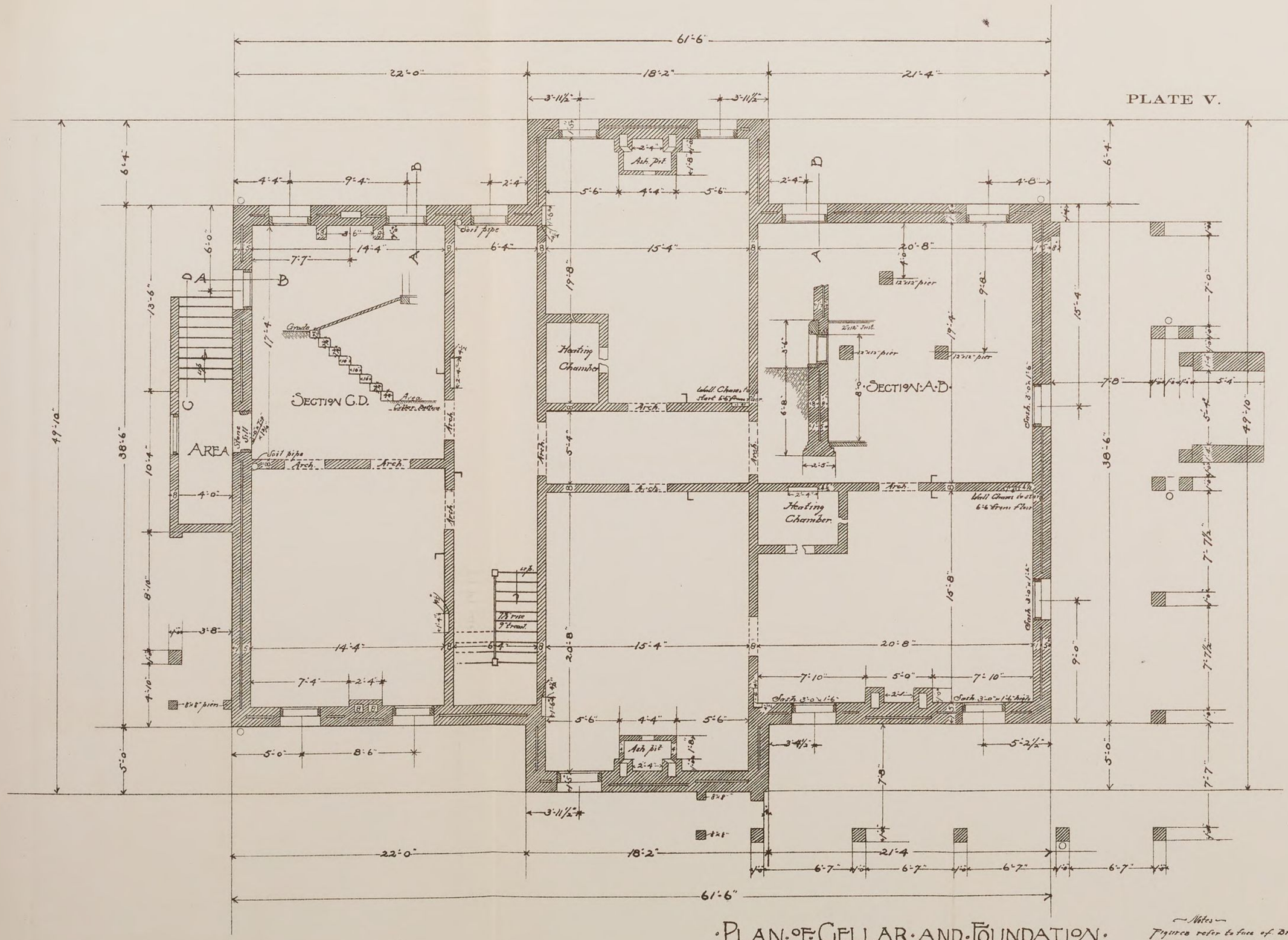
SCALE 1/4 INCH = 1 FOOT.

HOUSE A.

Ord 53 2

Appendix 12 1893.





PLAN OF CELLAR AND FOUNDATION

SCALE ¼ INCH = 1 FOOT.

HOUSE "A."

Notes
Figures refer to face of Brickwork.
└ Indicates Gas Outlets.

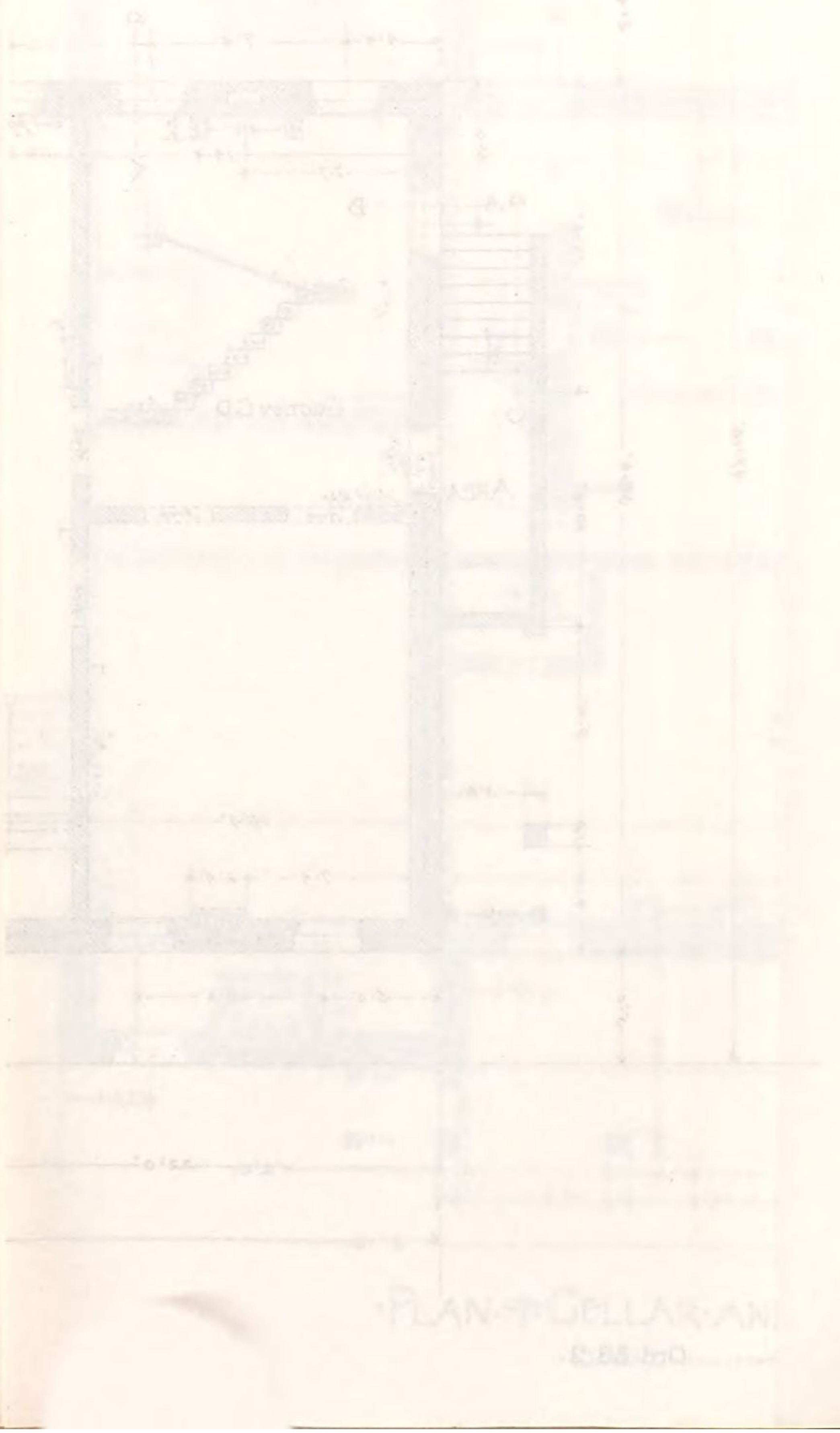
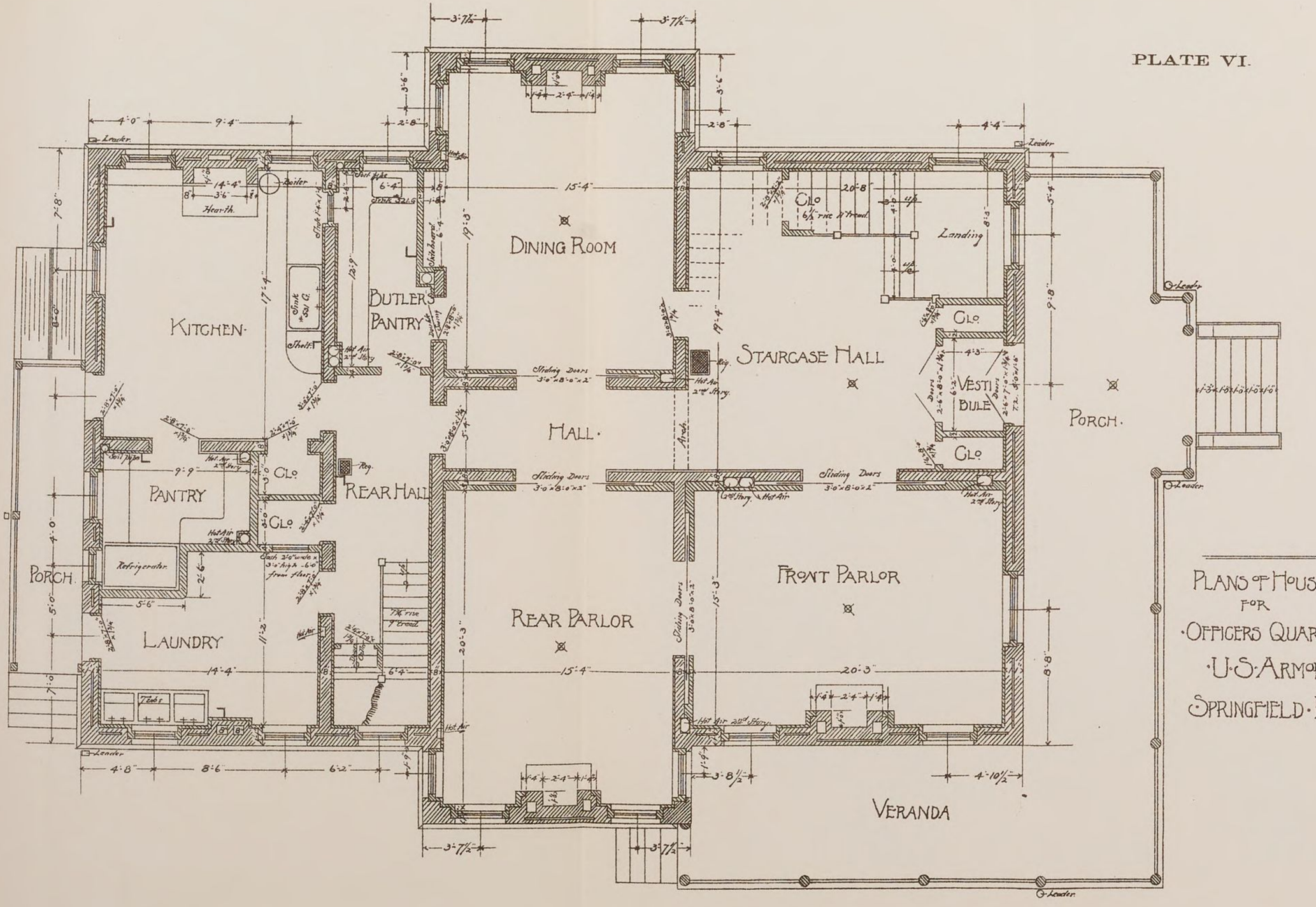


PLATE VI.



PLANS OF HOUSE
FOR
·OFFICERS QUARTERS·
·U·S·ARMORY
·SPRINGFIELD·MASS·

·PLAN·OF·FIRST·FLOOR·

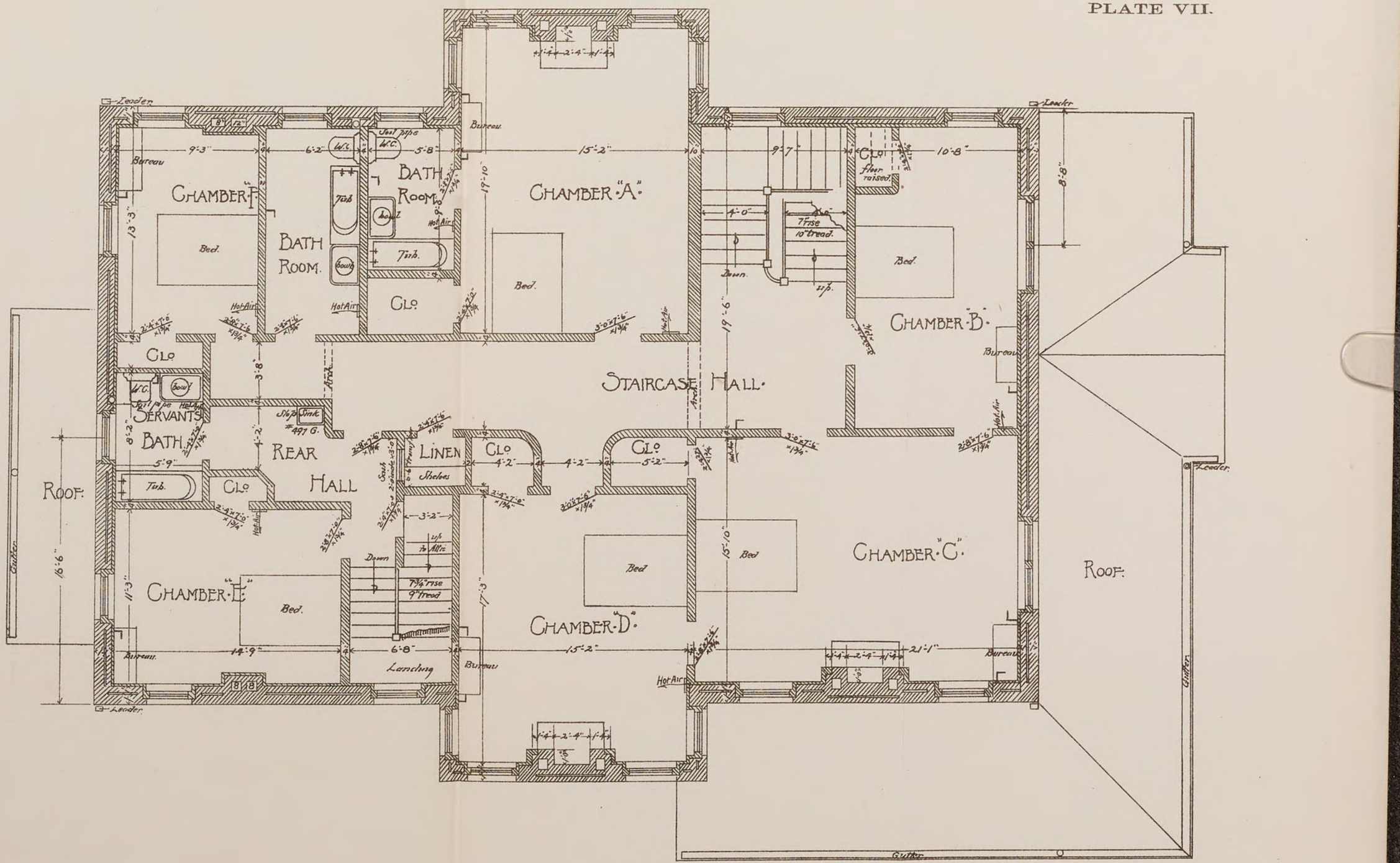
SCALE 1/4 INCH = 1 FOOT.

·HOUSE·"A"·

Notes—
Figures refer to face of Studs and face of Brick work.
⊠ L Indicate Gas Outlets.

Ord 53 2

Appendix 12, 1893.



PLAN OF SECOND FLOOR

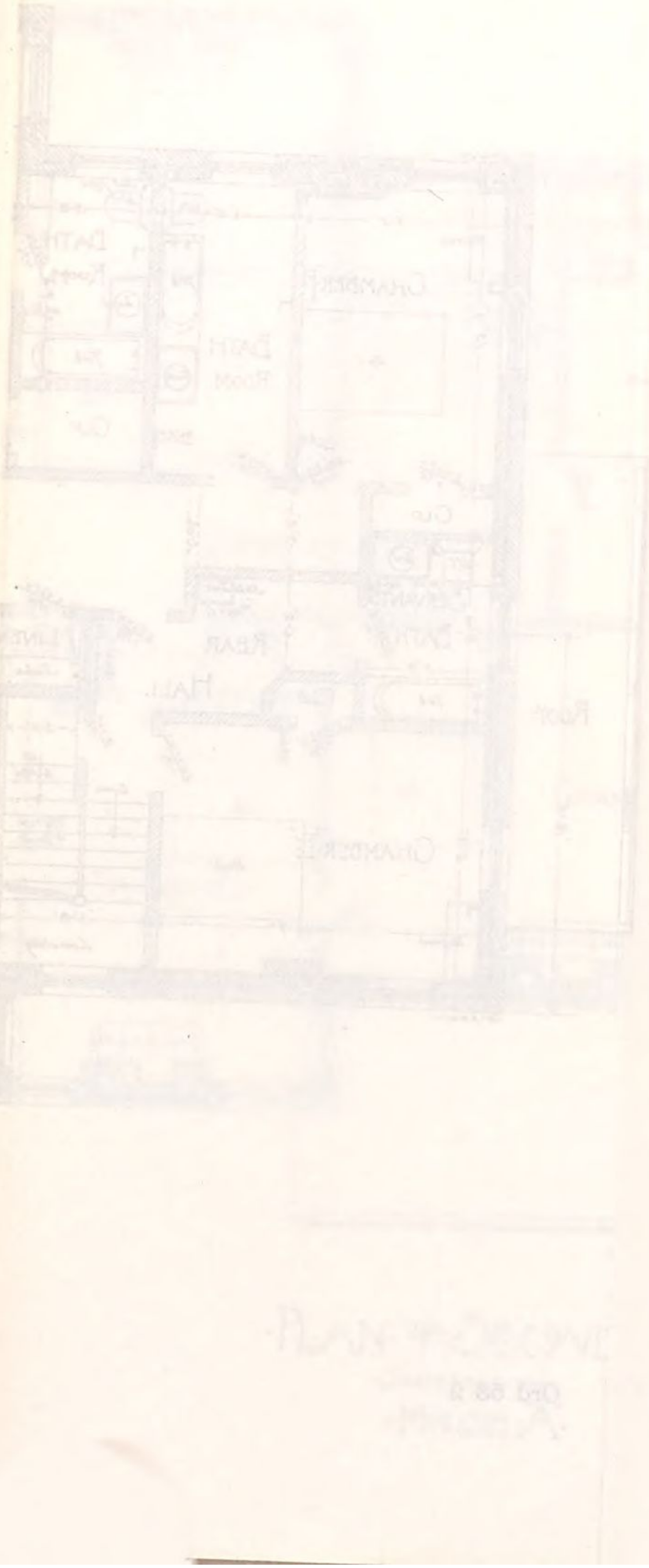
SCALE 1/4 INCH = 1 FOOT

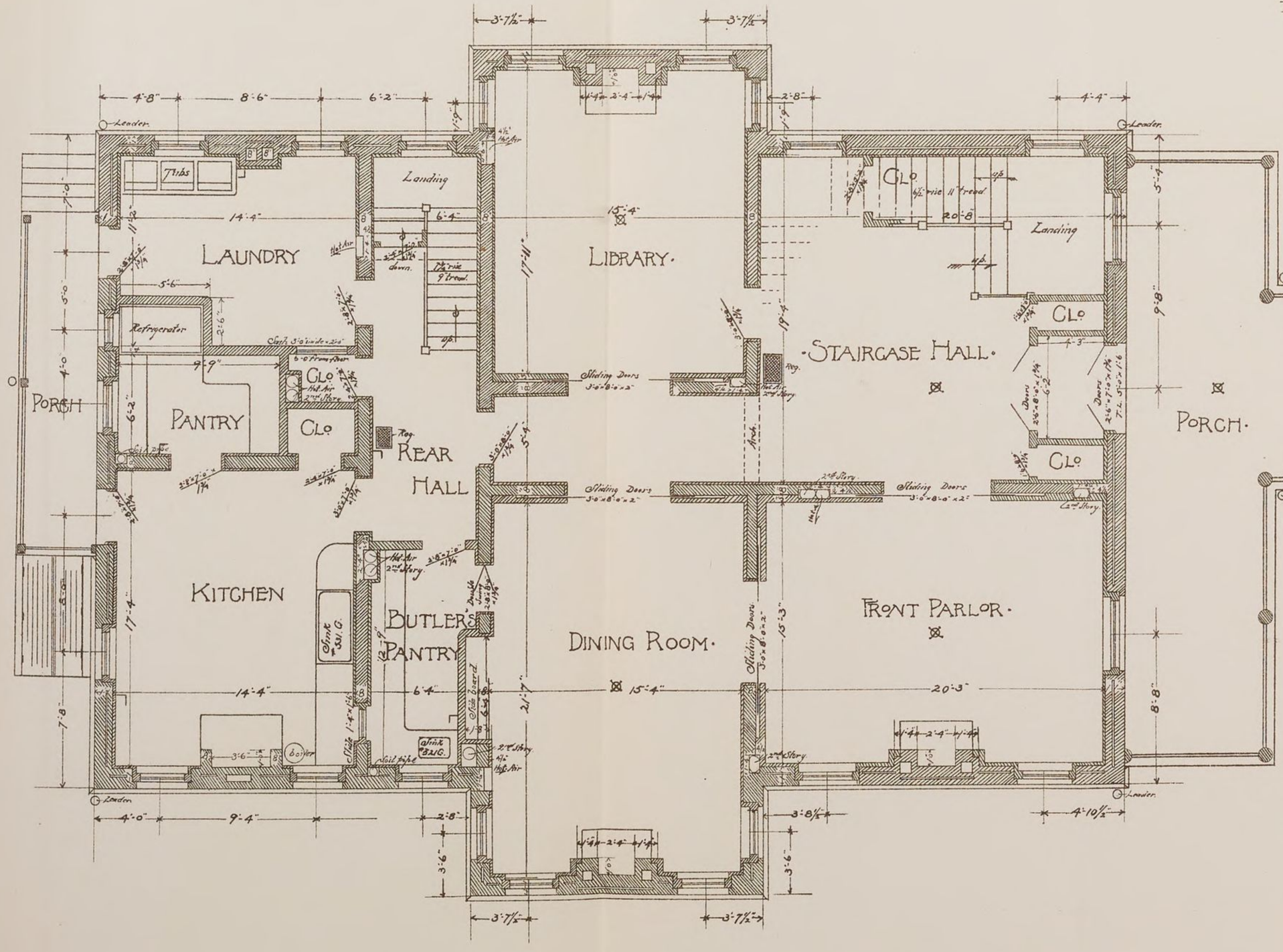
HOUSE "A"

Appendix 12 1893.

—Notes—
Figures refer to face of Studs
cased face of Brickwork.
L Indicates Gas Outlets
Windows not figured come
over those below.

Ord 53 2



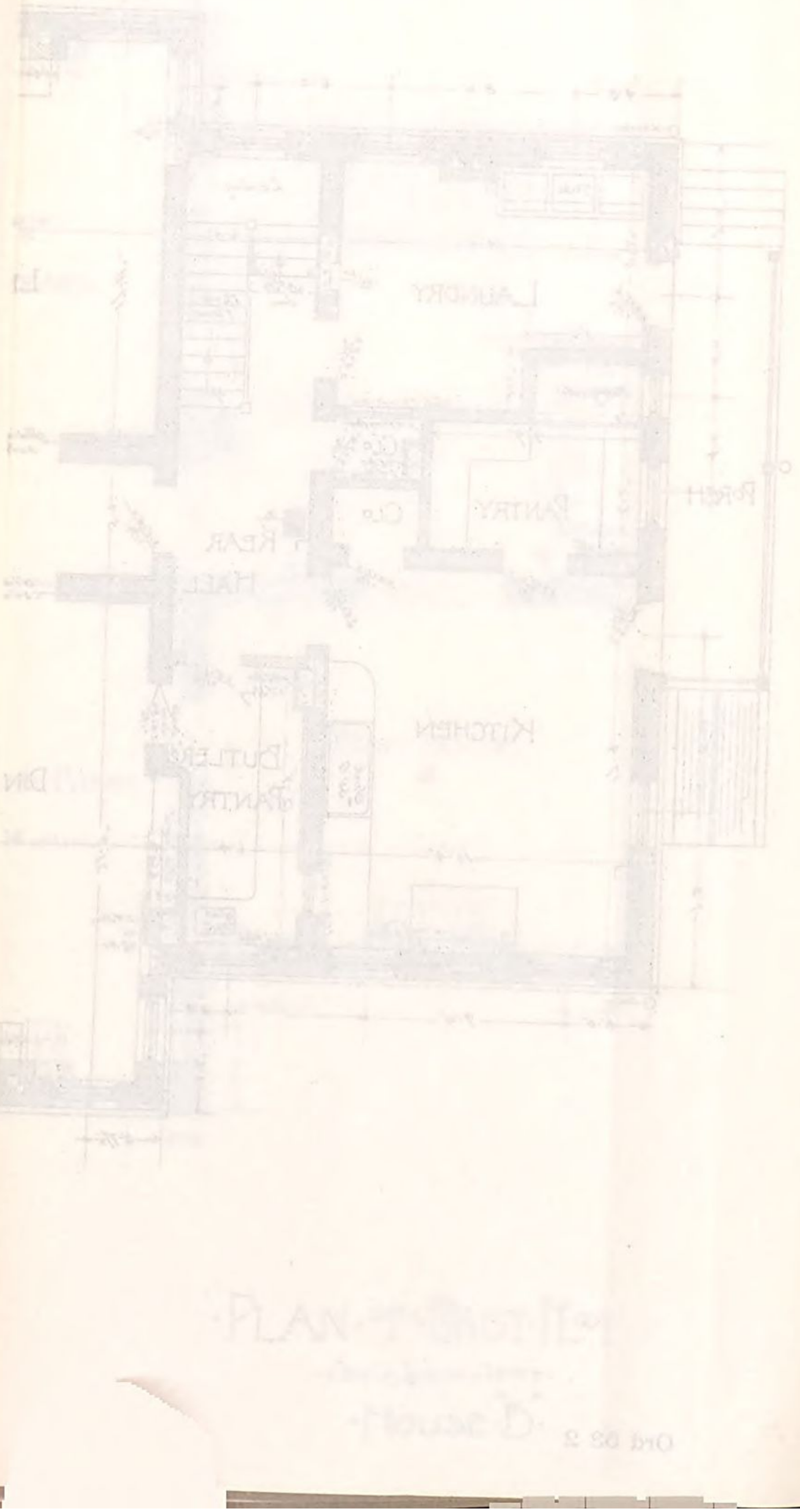


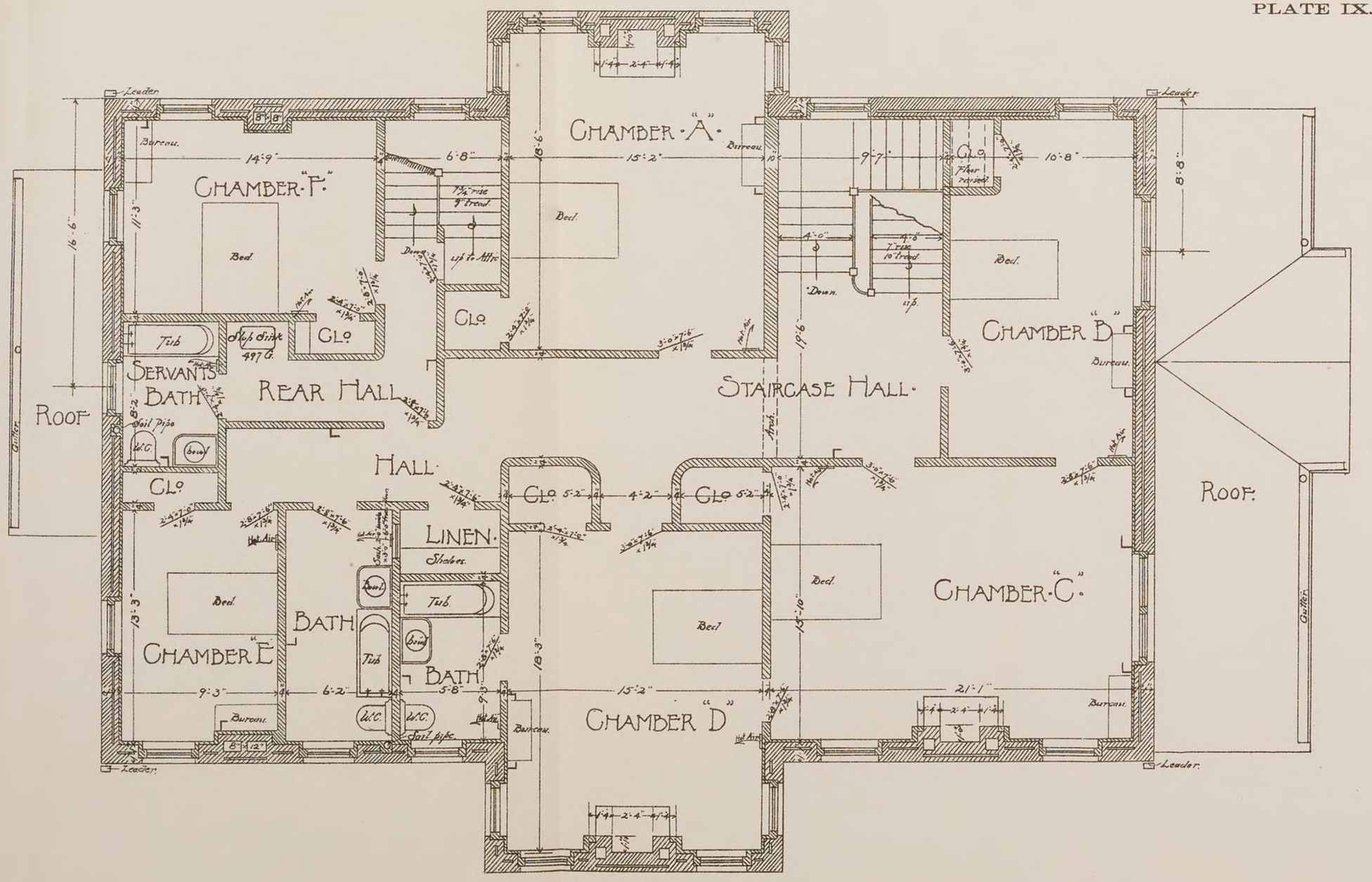
PLANS OF HOUSE
FOR
OFFICERS QUARTERS
·U·S·ARMORY·
·SPRINGFIELD·MASS·

·PLAN·OF·FIRST·FLOOR·

·SCALE 1/4 INCH = 1 FOOT·
" "
·HOUSE·B·

—Notes—
Figures refer to face of Studs and face of Brickwork
⊠ L Indicates Gas Outlets.


LAUNDRY
PANTRY
KITCHEN
BUTLER'S
PANTRY
HALL
REAR
PORCH



Ord 53 2

PLAN OF SECOND FLOOR.

SCALE ¼ INCH = 1 FOOT.

HOUSE "B".

Appendix 12, 1893.

Notes

Figures refer to face of studs and face of Brickwork.

L Indicates Gas Outlets.

Windows not figured come over those below.

ROOF
CHAMBER
BATH
HALL
LIBRARY
CLO
PLAN OF SECOND
HOUSE D

APPENDIX 13.

DESCRIPTION OF COLT'S DOUBLE-ACTION REVOLVER, ARMY MODEL 1892, WITH RULES FOR MANAGEMENT, MEMORANDA OF TRAJECTORY, AND DESCRIPTION OF AMMUNITION.

(4 plates.)

[Prepared at the Springfield Armory, Massachusetts, by Capt. D. M. Taylor, Ordnance Department, U. S. Army, under the direction of Col. Alfred Mordecai, commanding.]

Component parts for Colt's revolver, army model 1892, caliber .38.

[The numbers and letters used on some of the parts below are the same as in the plates.]

Stocks (2), right and left.
Escutcheons (2), threaded and plain.
No. 2, stock screw.
Stock pin.
Side plate.
No. 19, side plate screws (2).
Crane.
No. 10, crane lock.
No. 11, crane-lock screw.
Crane bushing.
Cylinder.
a. Ejector.
Ejector rod.
No. 14, ejector-rod head.
No. 9, ejector spring.
Latch.
No. 15, latch spring.
No. 13, latch-spring pin.
Barrel, complete, with sight.
No. 3, hammer.
No. 4, hammer stirrup.
No. 5, hammer-stirrup pin.
No. 6, hammer strut.
No. 7, hammer-strut pin.
No. 8, hammer-strut spring.
Hammer pin.
No. 18, hand.
c. Hand spring.
No. 20, mainspring.
Main spring tension screw.
No. 12, trigger.
Trigger pin.
No. 17, cylinder bolt.
Cylinder-bolt spring.
No. 1, rebound lever.
Rebound-lever pin.
No. 16, rebound spring.
Rebound-spring pin.
b. Recoil plate.
Frame.

Dimensions of Colt's revolver, army model 1892, caliber .38.

Weight	pounds	2
	ounce	1
Total length	inches	11.5
Barrel:		
Length	do	6.
Diameter of bore	do	0.363
Rifling, number of grooves		6
Grooves (style, uniform):		
Width	inches	0.156
Depth	do	0.003
Twist, one turn in	do	16.
Lands, width	do	0.03406
Cylinder:		
Length	do	1.499
Diameter	do	1.52
Chambers:		
Number		6
Diameter	inches	0.3825
Front sight, top to axis of bore	do	0.6045

OPERATION OF THE PARTS.

The annexed plates present views of the Colt's double-action revolver, army model 1892, caliber .38.

Plate 1 shows a side elevation of the revolver with the cylinder

closed. Plate 2, a longitudinal section with the essential parts of the mechanism exposed to view. Plate 3, the principal component parts shown separately.

This revolver, while admitting of the simultaneous ejection of the cartridge shells from all of its chambers, has a solid frame. In other words. the barrel and grip are rigidly and immovably connected, thus avoiding moveable joints, whose wear is apt to destroy the accuracy and durability of the arm, features essential for a military weapon.

To eject the shells and to load, the cylinder is swung laterally out of the frame. This is effected by means of a crane which supports the cylinder on a central arbor and is attached to the frame by a pivot below the cylinder mortise. The barrel is securely screwed in the frame, and to insure the accurate alignment of the axis of the firing chamber with that of the barrel, both the cylinder arbor and the crane pivot are made as long and of as large a diameter as practicable. The crane is confined in the frame by an annular shoulder on the pivot, against which the crane lock bears, the latter being held in place by a screw.

In front of the cylinder the crane fits into a suitable recess in the frame under the barrel, and at the rear the cylinder ratchet enters a recess in the recoil face; thus securely supported, the crane and cylinder, when closed, are locked in the frame by the cylinder latch, which slides longitudinally on the left side of the frame. A central projection from the latch enters a corresponding recess in the ratchet. A thumb piece on the latch serves to draw it back; then crane and cylinder are free to swing to the left, out of the frame.

The ratchet is integral with the ejector (*a*), which fits in a recess in the rear face of the cylinder, and, by a left-hand screw thread is fixed to the ejector rod, which terminates at its front end in the head (14). This rod is grooved and corresponds with a splined bushing fixed in the cylinder, insuring the revolution of the rod with the cylinder. Two short studs, fitting cuts in the periphery of the ejector, force it to rotate with the cylinder.

The ejector rod passes through the center of the cylinder arbor of the crane and projects under the barrel, terminating in a knob. The ejector spring, coiled around the rod, its front end bearing against a collar on the rod and its rear end against a bushing (*e*), which closes the arbor chamber, serves to hold ejector and rod in such position as will admit of the cylinder being swung into the frame, except when the ejector rod is pressed.

When the crane and cylinder are swung out, pressure against the front end of the ejector rod will empty all chambers of the cylinder, the ejector spring returning ejector and rod to the position for closing cylinder when the pressure is removed. A shoulder on the frame prevents the cylinder from sliding rearward off its arbor. As the cylinder swings back into the frame a bevel on the face of the latch moves the latter back until the ratchet has passed, when the latch is closed by the action of its spring, its central projection being, by this spring, forced into, and held in, the recess in the center of the ratchet, thus locking the cylinder in the frame.

The mechanism for rotating the cylinder and the lock are independent of the ejecting device, except that the hammer can not be brought to full cock while the cylinder is turned out of the frame; nor can the cylinder be so turned out while the hammer is at full cock. The object of this is to prevent accidental firing. The safeguard against this consists in providing a slot in the end of the crane pivot, in which a projection on the forward part of the trigger engages when the latter is

pressed while the cylinder is closed, thus preventing rotation of the crane arbor; but when the cylinder is swung out and the crane pivot rotates its slot is no longer in position to receive the projection on the trigger, and the latter can not be moved enough to allow the cocking of the hammer. A plate on the right side of the frame, held by two screws (19), covers the lock.

The limb work of the lock consists of the hammer (3), with strut (6), strut spring (8), and stirrups (4); the trigger (12), the hand (18), with its spring (c), the rebound lever (1), the bolt with its spring (17), the mainspring (20), and the rebound spring (16).

When the hammer is cocked by means of its thumb piece it pulls back the trigger until the point of the latter falls into the full-cock notch, where it holds the hammer ready for firing.

For rapid firing the trigger alone is used. As it is pulled back its point raises the hammer by bearing under the hammer strut (6) until, as the hammer approaches the full-cock position, the point of the strut escapes from the trigger point, when the hammer, by reason of the tension of the mainspring (20), transmitted through the stirrup (4) and stirrup pin (5), falls and strikes the cartridge. When the pressure on the trigger is relaxed and it returns to its position of rest, the strut, being pivoted to the hammer by the strut pin (7), yields so as to allow the trigger point to descend past it, when the action of the strut spring (8) throws the strut above the trigger point.

The rebound lever (1) is pivoted under the hammer and in rear of the trigger, its rear end supported by the rebound spring (16). An arm of the rebound lever extends forward to the right side of the trigger, a small slot at the end of the arm fitting over a small stud on the trigger. When the trigger moves back as the hammer is cocked it raises this arm of the lever and removes the rebound lever from the path of the hammer, so the latter may fall unobstructed. On the release of the trigger the arm of the lever falls, the rebound spring raising the rear end, the upper portion striking against the foot of the hammer, rams it back to its safety position, the connecting arm of the lever returning the trigger to its position. The hammer strut (6), after the trigger point has passed it, standing above the latter locks the hammer securely in this safety position. A screw in the frame, just below where the rebound lever is attached, serves to regulate the tension of the mainspring.

The hand (18) is attached by its pivot to the trigger, and as the latter moves back while the hammer is being cocked the hand is raised and rotates the cylinder. Two points of the hand act on the teeth of the ratchet, which are placed centrally between adjacent chambers of the cylinder; on the first movement of the trigger the upper point of the hand engages the ratchet tooth above it, and revolves the cylinder partly, but before the necessary sixth of a revolution is made, as the hand moves in a vertical plane and the ratchet tooth in the arc of a circle, the tooth escapes laterally from the point. Before this occurs the lower point of the hand has engaged the next tooth and completes the revolution. By this construction of the ratchet and the double action of the hand the latter operates the cylinder at a greater distance from the center of revolution, thus gaining force, while the increased diameter of the ratchet and the greater strength of its teeth are made possible without increasing the diameter of the cylinder. Besides the radial shoulders of the teeth under which the points of the hand engage there is on each tooth a second shoulder at right angles to the first one; at the end of a sixth of a revolution this shoulder is

parallel to and in line with the inner or left side of the hand; as the latter cannot yield laterally, being guided in a vertical slot in the recoil face of the frame, the cylinder is prevented from rotating too far.

When the trigger is released and moves forward the hand descends and the hand spring (*c*) yielding allows the upper point of the hand to slide downward on the inclined back of the tooth in front of it until it has passed this, when the spring urges it forward under the tooth in readiness for another partial revolution when the trigger is pressed.

Independently of the hand, the cylinder is positively stopped at the firing point (where the hammer nose is exactly in line with the axis of the chamber, and this latter becomes a prolongation of the bore of the barrel) by a projection on upper part of the trigger and just in rear of its pivot (*g*, Fig. 3). The last movement of the trigger caused this projection to protrude from a hole in the bottom of the cylinder mortise and in the path of one of the shoulders cut in the periphery of the cylinder near its rear end. When this projection engages the shoulder further rotation is prevented. To prevent the rotation of the cylinder when trigger and hammer are at rest the cylinder bolt (17) is hung on the trigger pivot, its nose projecting in front of this, through another hole in the bottom of the cylinder mortise, into one of a series of notches on the surface of the cylinder. The first movement of the trigger to the rear withdraws this bolt nose, allowing the cylinder to be rotated by the action of the hand, and the release of the trigger again allows the nose of the bolt to protrude. A spring, fastened in a slot in the bolt, allows the latter to yield, if the cylinder, after being out of the frame, is returned in such position that neither of its notches comes above the bolt nose; but at the first rotation of the cylinder the bolt enters the first notch that passes over it and locks the cylinder. This serves to prevent displacement of the cylinder while the pistol is in the holster, and insures the next loaded chamber coming in front of the hammer when the pistol is drawn for use, if it has been put up without reloading chambers previously fired.

After pulling off the hammer, when the pressure on the trigger is released, the hand descends, its spring yielding and allowing the tooth of the hand to slide over the tooth of the ratchet. This action has a tendency to rotate the cylinder in the wrong direction and bring a chamber, which has just been fired, again in line with the barrel. To prevent any possibility of this the latch has, just to the left of the cylindrical bolt which enters the recess in the center of the ratchet, a slight projection which engages the ratchet in such manner as to prevent rotation in this direction. The other side of this projection presents an inclined plane to the ratchet teeth which slide over it, pushing the latch back slightly.

MANAGEMENT.

The pistol is dismounted in the following order: (1) Remove stock screw and stock. (2) Unlock crane by partly drawing out the crane-lock screw and remove crane and cylinder. (3) Remove side-plate screws and side plate. (4) Remove hand and hand spring. (5) Remove main spring. (6) Remove hammer, rebound lever, bolt and trigger. (7) Remove rebound spring. To assemble, reverse this order.

In order to remove the cylinder from the crane the ejector is unscrewed from its rod and the rod and spring are taken from the crane by removing the knob from the rod and unscrewing the bushing from the rear end of the arbor. The threads, in ejector and rod, and in the arbor for the bushing, are left handed. These parts should not be unscrewed unless a broken rod, ejector, or spring renders it necessary.

If the cylinder be very nearly closed but not sufficiently so for the latch to lock it, a strong pressure upon the trigger will bring the hammer to full cock and pull it off. This is caused by the projection on the forward part of the hammer shearing part of the wall of the slot in the end of the crane pivot. Each time that this occurs the injury to the end of the crane pivot increases. Experiments with unloaded but primed shells have failed, however, to explode the primer unless the cylinder was so nearly closed that the firing chamber was practically a prolongation of the barrel, since a very slight throwing out of the cylinder is sufficient to move the primer out of the reach of the nose of the hammer. Soldiers should be instructed to be certain that the cylinder is securely closed before attempting to cock the revolver, either as a single action pistol or by means of the trigger.

If it becomes necessary to replace a hand in a revolver it is important that it be so adjusted that the upward movement of the hand does not begin to rotate the cylinder before the movement of the trigger has withdrawn the cylinder bolt. To insure this it may be necessary to file the hand slightly at the end which first engages the ratchet, and as this may bring the two points of the hand which engage the teeth of the ratchet too near together the lower projection of the hand may also have to be slightly filed.

In removing the side plate no attempt must be made to pry it out. Holding the pistol in the left hand, strike the frame on the part usually covered by the wood of the stock smart blows with a piece of wood until the side plate is jarred out of place.

The tension screw is intended to increase the striking force of the hammer when necessary. When it is screwed into the frame it bears against the mainspring and increases its tension. All revolvers are proved with the "tension screw" out of the pistol to insure the mainspring being sufficiently strong before it has been used, and care should be taken that this screw be not screwed in unnecessarily. If it be, the force of the blow may cause the nose of the hammer to pierce the primer. When it is necessary to alter the tension of the spring it should be done with great care, as a very slight movement of the screw affects the mainspring greatly.

Material in army revolver, model of 1892.

Stocks, American walnut.
Escutcheons, German silver.
Stock screw, iron gun-screw wire.
Stock pin, Bessemer steel.
Frame, special steel.
Frame cap, special steel.
Frame-cap screws, iron gun-screw wire.
Crane, crucible steel.
Crane lock, steel drill rod.
Crane-lock screw, iron gun-screw wire.
Crane bushing, Bessemer steel.
Cylinder, open-hearth steel (imported).
Ejector, crucible steel.
Ejector rod, drawn-steel rod.
Ejector-rod head, Bessemer steel.
Ejector spring, spring wire, 10 per cent. silver.
Latch, crucible steel.
Latch spring, spring wire, 10 per cent. silver.
Latch-spring pin, steel drill rod.
Barrel, special steel.
Hammer, crucible steel.
Hammer stirrup, Bessemer steel.
Hammer-stirrup pin, drawn-steel rod.
Hammer strut, crucible steel.
Hammer-strut pin, drawn-steel rod.
Hammer-strut spring, spring steel.
Hammer pin, drawn-steel rod.
Hand, crucible steel.
Hand spring, spring steel.
Mainspring, spring steel.
Mainspring tension screw, iron gun-screw wire.
Trigger, crucible steel.
Trigger pin, drawn-steel rod.
Cylinder bolt, spring steel.
Cylinder-bolt spring, spring steel.
Rebound lever, crucible steel.
Rebound-lever pin, drawn-steel wire.
Rebound-lever spring, spring steel.
Rebound-lever spring pin, drawn-steel wire.
Recoil plate, Bessemer steel.
Screw-driver, spring steel.

MEMORANDA OF TRAJECTORY, COLT'S DOUBLE-ACTION REVOLVER, CALIBER .38, ARMY MODEL 1893.

1. Rapidity of fire.

This pistol can be fired 18 times in forty-four seconds, loading each chamber separately, and beginning and ending with cylinder closed and chambers empty. Using the "loading pack" furnished by the Colt's Patent Fire-arms Manufacturing Company, 18 shots have been fired in twenty-nine seconds, beginning and ending as above stated. This was firing without aim.

Aiming at 25 yards distance, at a figure slightly smaller than that of an average man and using the pistol as a self-cocker, the chambers being loaded separately, 18 shots have been fired in one minute and twenty-four seconds, giving 13 hits. Using the pistol as a "single-action" weapon the same number of hits in 18 shots have been obtained in one minute and twenty-seven seconds.

Aiming at the same figure, and at the same distance with the loading pack, 16 hits out of 18 shots have been made in one minute, using the pistol as a self-cocker, and in one minute and twenty-five seconds as a "single-action" weapon.

2. Accuracy.

Deviations.	25 yards.	50 yards.	75 yards.	100 yards.	150 yards.	200 yards.
	Inch.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Mean horizontal	0.668	0.604	2.278	2.400	2.762	4.600
Mean vertical	0.515	1.400	1.612	1.994	7.296	6.990
Mean radial	0.903	1.553	2.884	3.656	8.018	9.255

3. Drift.

The drift or deviation due to the rifling is, in this arm, to the left, and is more than neutralized by the pull of the trigger when the pistol is fired from the right hand.

Careful firings made with a pistol with right hand and one with left-hand rifling of the service pitch, the weapons being carefully sighted and clamped in a fixed rest, gave the following as the drift:

At 25 yards.	At 50 yards.	At 75 yards.	At 100 yards.	At 150 yards.
Inch.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0.75	1.09	1.57	2.24	7.80

The result of these firings indicated that but little reliance could be placed on results obtained at over 75 yards. A very slight variation in the ammunition produced such widely-varying results at the longer ranges as to render even an average of many results unreliable and misleading.

4. Recoil.

Weight of revolver.	Weight of powder charge.	Weight of ball.	Recoil (theoretical).
Pounds.	*Grains.*	*Grains.*	*Feet pounds.*
2.06	16	150	1.998

5. *Penetration in white pine.*

Range in yards.	25.	50.	75.	100.	150.	200.
Depth in inches.....	4.97	4.35	4.26	3.64	3.05	2.90

A penetration of 1 inch in white pine corresponds to a dangerous wound.

6. *Velocity.*

The muzzle velocity of this weapon with the Frankford Arsenal cartridge, with 16 grains of powder and 150-grain bullet, is 708.3 feet-seconds. The instrumental velocity was obtained by means of the Le Boulengé chronograph, taking a mean of 20 shots. The remaining velocities at the various ranges were calculated by the aid of the formulæ and tables in Ingalls' Handbook of Problems in Direct Fire.

Remaining velocity.

At 25 yards.	At 50 yards.	At 75 yards.	At 100 yards.	At 125 yards.	At 150 yards.	At 175 yards.	At 200 yards.
Ft. secs. 689.9	*Ft. secs.* 671.9	*Ft. secs.* 654.5	*Ft. secs.* 637.5	*Ft. secs.* 620.9	*Ft. secs.* 604.8	*Ft. secs.* 589.09	*Ft. secs.* 573.8

7. *Force of impact.*

At 25 yards.	At 50 yards.	At 75 yards.	At 100 yards.	At 125 yards.	At 150 yards.	At 175 yards.	At 200 yards.
Ft. lbs. 155.2	*Ft. lbs.* 147.2	*Ft. lbs.* 139.7	*Ft. lbs.* 132.5	*Ft. lbs.* 125.7	*Ft. lbs.* 119.3	*Ft. lbs.* 113.2	*Ft. lbs.* 107.4

8. *Dangerous space.*

The following tables show the dangerous space for this arm, at ranges from 25 to 200 yards, under the varying conditions of the weapon being used by both mounted and foot troops and against each of these.

The height of a mounted man is, as usual in determinations of dangerous spaces, taken to be 96 inches, and the height of a foot soldier 68 inches. The weapon is supposed to be fired from the height of the eye or 92 inches for a mounted man and 64 inches for a foot soldier. The points aimed at with mounted and foot soldiers, respectively, are 84 and 34 inches from the ground.

The determination of dangerous spaces was made by firing the revolver from a fixed rest, through screens, and by means of the holes made by the bullet determining the actual trajectory. A number of these were measured and the mean trajectory taken. By graphical representation the dangerous spaces were then laid off and measured.

INFANTRY AGAINST CAVALRY.

Distance.	Ascending branch of trajectory.	Descending branch—		Maximum continuous dangerous space.	Total dangerous space.
		Before object.	Beyond object.		
Yards.	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*
25	.....	All.	56.8	81.8	81.8
50	.....	All.	63.2	113.2	113.2
75	.....	All.	57.4	132.4	132.4
100	.....	All.	52.5	152.5	152.5
150	.....	All.	51.0	201.0	201.0
200	24.2	80.8	45.0	125.8	150.0

INFANTRY AGAINST INFANTRY.

25	.....	All.	25.6	50.6	50.6
50	.....	All.	49.3	99.3	99.3
75	.....	All.	39.9	114.9	114.9
100	.....	All.	34.75	134.75	134.75
150	12.25	49.2	34.6	83.8	96.05
200	7.0	43.1	30.6	73.7	80.7

CAVALRY AGAINST INFANTRY.

25	.....	14.2	13.8	27.0	27.0
50	.....	27.8	24.25	52.05	52.05
75	.....	39.4	27.3	66.7	66.7
100	.....	43.4	27.0	67.4	67.4
150	.....	36.9	28.9	65.8	65.8
200	.....	35.5	27.2	62.7	62.7

CAVALRY AGAINST CAVALRY.

25	All.	All.	25.0	50.0	50.0
50	All.	All.	40.2	90.2	90.2
75	All.	All.	42.0	117.0	117.0
100	All.	All.	41.2	141.2	141.2
150	27.5	80	40.3	120.3	147.8
200	8	59	39.8	98.8	106.8

IMPORTANT POINTS.

(1) The revolver should be kept clean, free from rust, and well oiled.

(2) The tension screw should never be screwed in tightly unless the mainspring fails to explode the primer. If screwed in, unless the spring is weak, it will so increase the force of the blow of the hammer that pierced primers will result.

(3) The limb-work of lock must not be tampered with. The side plate should never be removed except under the supervision of a non-commissioned officer.

(4) Never remove side plate by prying it out of place. Hold the pistol, with wood part of stock removed, in the left hand, side plate slightly inclined down. Strike smart blows with a piece of wood on the part of the frame usually covered by the wood of the stock until the plate is jarred out of place.

(5) Be sure the cylinder is fully closed and the latch in place before firing or snapping the revolver.

(6) Never attempt to open the cylinder when the revolver is cocked.

DESCRIPTION OF SOLID-HEAD RELOADING CARTRIDGE FOR COLT'S ARMY REVOLVER, CALIBER .38.

PLATE IV.

This consists of a cylindrical brass case containing 16 grains small-arms powder, an exterior primer containing 0.1 grain of fulminating composition, and a lubricated lead bullet weighing 150 grains.

PRIMER.

The primer consists of a cup (*a*), which contains the primer composition, and an anvil (*b*), for resisting the blow of the firing pin. The anvil is pierced with two vents, by which the flame is communicated to the charge.

BULLET.

The form of the bullet is a cylinder surmounted by a conical frustum, which is surmounted by a spherical segment. Two rectangular cannelures contain the lubricant. There is a dished cavity in the base, by which the bullet is brought to proper weight without change of exterior form.

	Inches.
Length of bullet	0.72
Diameter of cylindrical part of bullet	0.357
Total length of cartridge	1.362

LUBRICANT.

The lubricant is Japan wax. The bullet enters the case far enough to entirely cover and protect the lubricant and, to render the cartridge waterproof, the case is tightly crimped around the bullet.

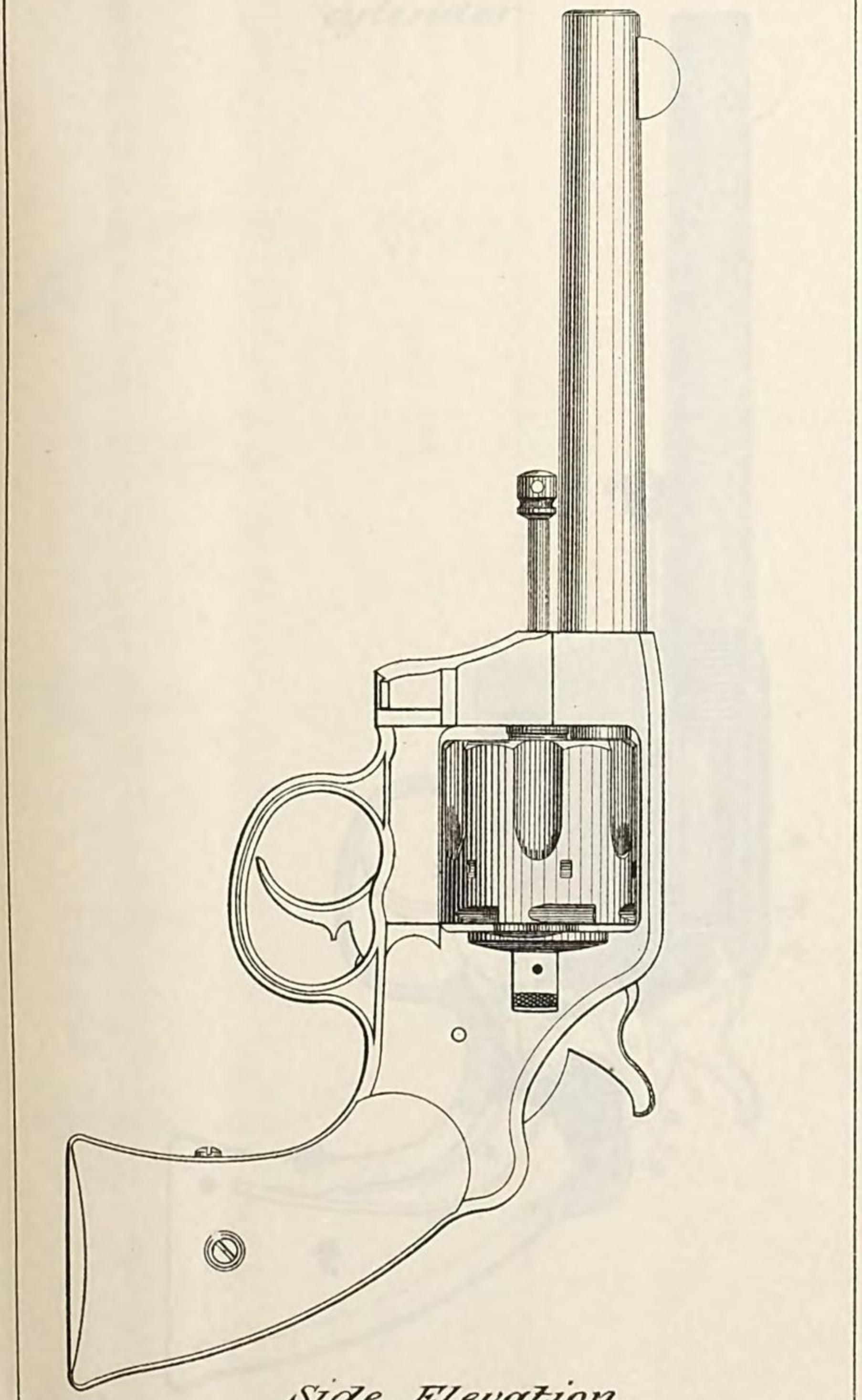
PACKING.

The cartridges are packed in pasteboard boxes containing 20 cartridges each. Fifty pasteboard boxes, or 1,000 cartridges, are packed in one wooden box.

	Pounds.
Weight of 100 cartridges	3
Weight of 1,000 cartridges packed	39

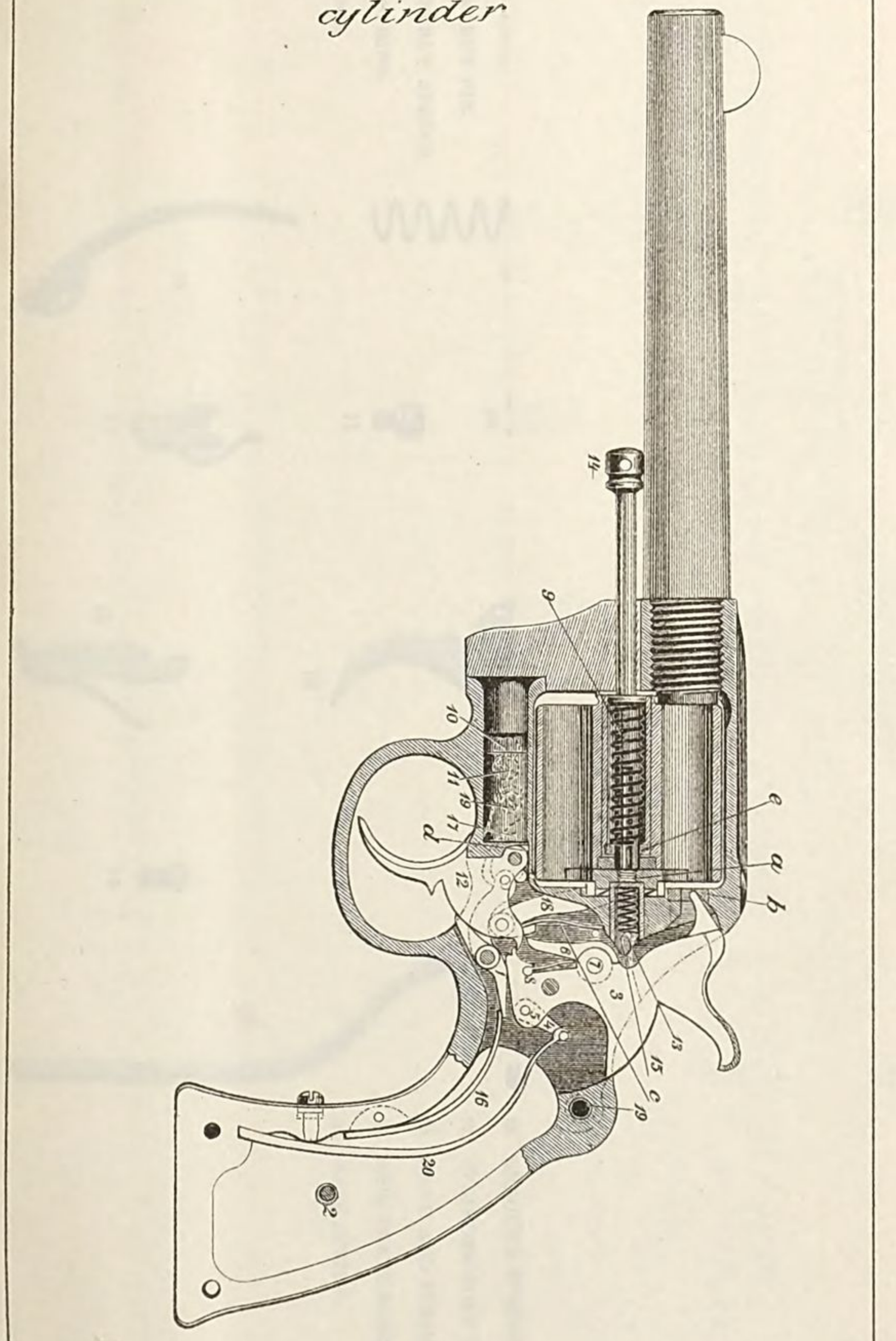
COLTS DOUBLE ACTION REVOLVER

ARMY MODEL. 1892. CAL. .38



Side Elevation

Longitudinal section showing relation of parts of limb-work of lock, frame and cylinder



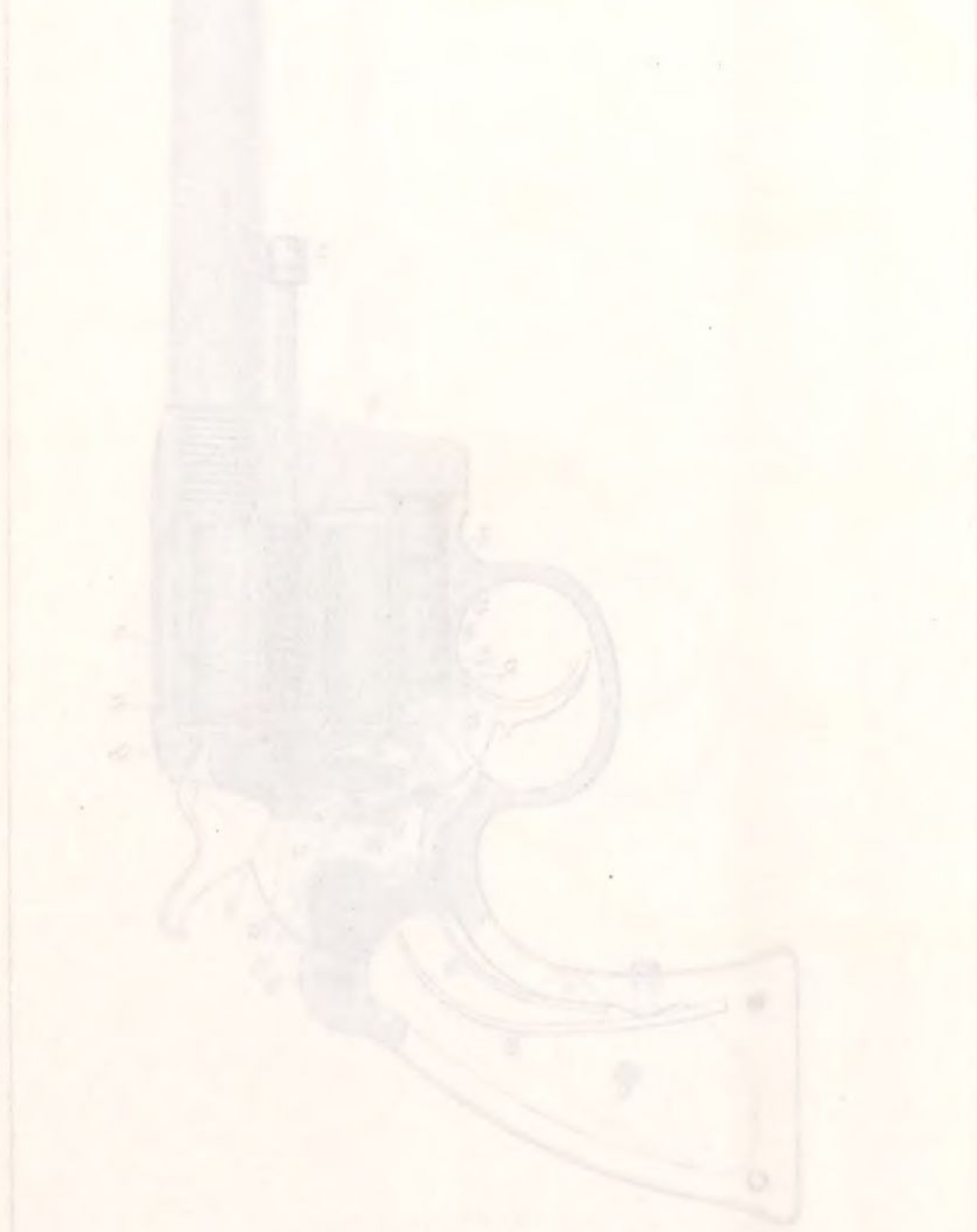


PLATE III.

Component Parts of New Army Double Action Revolver.
Model of 1892, .38 and .41 Calibres.

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1. REBOUND LEVER.
2. STOCK SCREW.
3. HAMMER.
4. HAMMER STIRRUP.
5. HAMMER STIRRUP PIN.
6. HAMMER STRUT.
7. HAMMER STRUT PIN.
8. HAMMER STRUT SPRING.
9. EJECTOR SPRING.
10. CRANE LOCK.
11. CRANE LOCK SCREW.
12. TRIGGER.
13. LATCH PIN.
14. EJECTOR ROD HEAD.
15. LATCH SPRING.
16. REBOUND SPRING.
17. CYLINDER BOLT AND SPRING.
18. HAND AND SPRING.
19. SIDE PLATE SCREW
20. MAIN SPRING.

9

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11

16

17

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18

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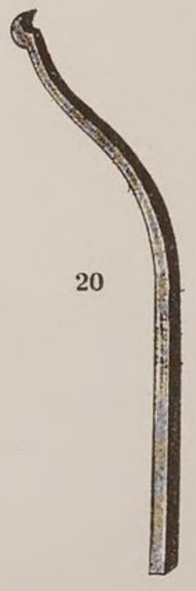
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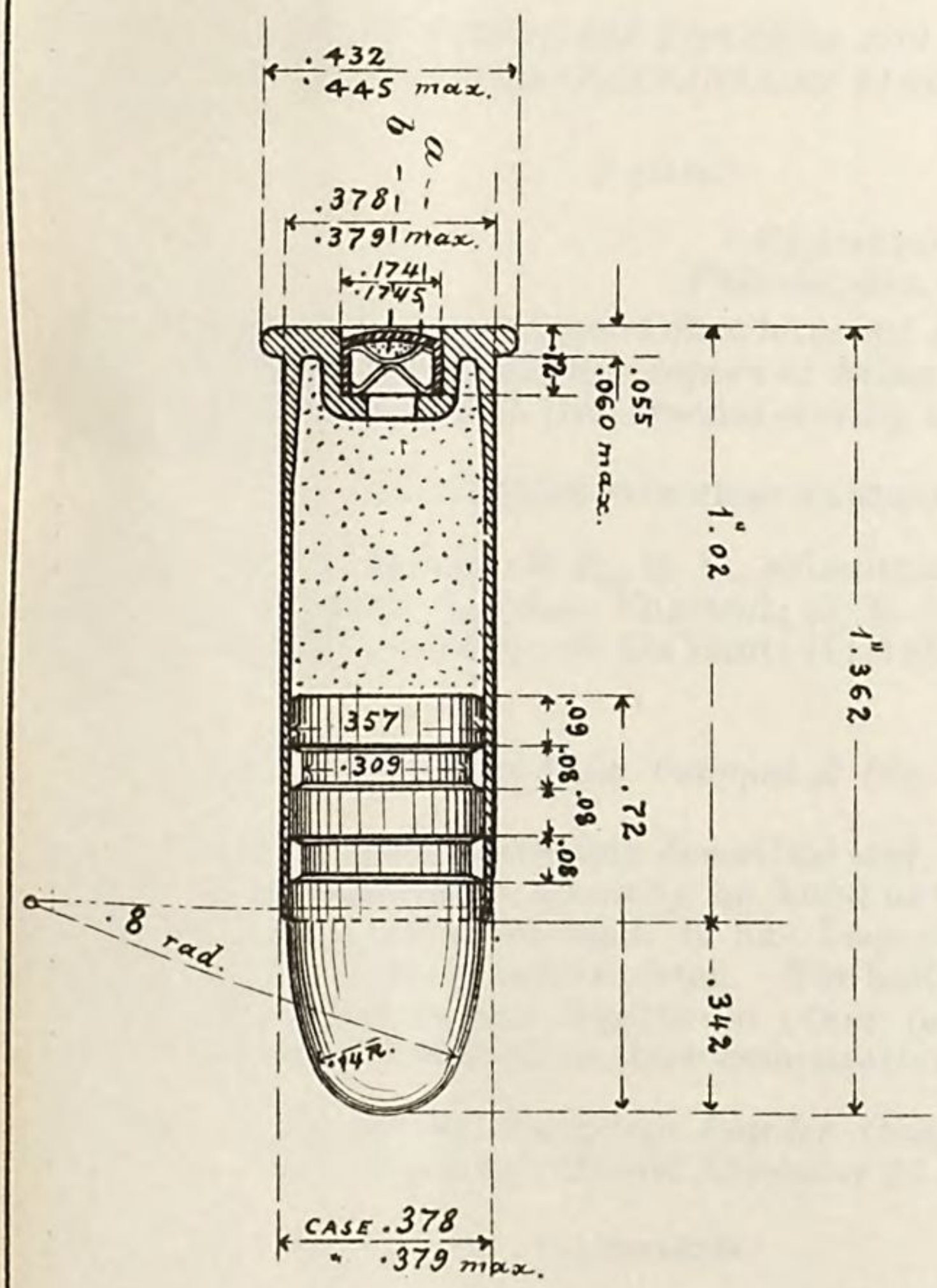
Cal. 38 Revolver Cartridge

Frankford Arsenal. October 1892



SCALE OF INCHES
1 0 .5 1

APPENDIX 14.

REPORT OF TESTS OF SMOKELESS POWDERS FOR SMALL ARMS AT THE FRANKFORD ARSENAL, PENNSYLVANIA, BY LIEUT. COL. J. P. FARLEY, COMMANDING.

(1 plate.)

FRANKFORD ARSENAL,
Philadelphia, Pa., June 30, 1893.

SIR: In obedience to Ordnance Office letter of June 22, 1893, I have the honor to submit the following report of firing tests of the various smokeless powders tested at this arsenal during the fiscal year ended June 30, 1893:

SMOKELESS POWDERS TESTED.

(1) Wetteren; (2) Rifleite, S. R., S. V., submitted by Smokeless Powder Company, Limited, London, England; (3) B. N. F.; (4) Peyton; (5) Leonard (numerous samples); (6) Du Pont; (7) Axtell; (8) Troisdorf; (9) Alters.

(1) *Wetteren (purchased from Cooppal & Cie, Liege, Belgium).*

This powder has been previously described and reported upon. On account of the considerable quantity on hand at the beginning of the year, and the fair results obtained, it has been used as a standard of comparison for the other powders tested. The ballistic results obtained with it will be found in the reports on other powders where it was taken as a standard and fired to show comparative results.

(2) *Powders submitted by Smokeless Powder Company, Limited, London, England. Tested November 15 to 18.*

(A) RIFLEITE.

This powder is black in color and of fairly regular granulation. Long and irregular grains occur, but not so frequently as with Wetteren powder. It was decided to test it in comparison with Wetteren powder, sieved and unsieved, using such charges of each as would give the muzzle velocity of 2,000 feet per second (1,960 feet per second at 53 feet from muzzle), prescribed by the caliber board, the resulting pressures to be carefully noted. In all of the tests a 230-grain bullet with German silver jacket, cannelured and lubricated, was used, this being the only pattern of which a suitable number was on hand. The strong Frankford Arsenal primer, having mealed powder in the fulminate composition, was used. This gave satisfactory results, except when small charges of powder were used, only partially filling the case.

The following table shows the results obtained with various charges:

Charge.	Rifle.	Number of shots.	Mean velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Mean pressure per square inch.	Remarks.
Grains.			*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	
37.....	Pressure..	7	1,778	150	30.0	Below 36,000.	Initial compression of pressure cylinders too great.
37.....	"A".....	10	1,759	37	10.5	.....	
38.....	"A".....	9	1,816	45	10.3	.....	
39.....	Pressure..	12	1,920	60	15.6	44,500.....	Average initial compression of pressure cylinders 37,500 pounds per square inch.
39.....	"A".....	10	1,949	73	22.1	Wad used....	
39.....	"A".....	5	1,952	48	14.4	.....	
39.....	Pressure..	5	1,946	54	24.8	43,000..... Wad used....	Average initial compression of pressure cylinders 41,000 pounds per square inch.
39.....	Pressure..	9	1,969	74	21.6	45,500.....	English primer used. Average initial compression of pressure cylinders 40,000 pounds per square inch.
39½.....	Pressure..	6	1,990	64	23.3	50,000.....	Average initial compression of pressure cylinders 38,000 pounds per square inch.
39½.....	"A".....	10	1,985	65	14.4	.....	
39½.....	Pressure..	5	1,999	40	14.2	53,500.....	Average initial compression of pressure cylinders 40,000 pounds per square inch.

The following results were obtained with charges of Wetteren powder, sieved and unsieved, fired at the same time for comparison:

WETTEREN POWDER, UNSIEVED.

Charge.	Rifle.	Number of shots.	Mean velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Mean pressure per square inch.	Remarks.
Grains.			*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	
36.....	"A".....	10	1,931	60	15.9	.....	
37.....	"A".....	10	1,972	66	16.7	.....	
37.....	Pressure..	8	1,993	80	16.7	42,000.....	Initial compression of pressure cylinders 40,000 pounds per square inch.

WETTEREN POWDER, SIEVED.

37.....	"A".....	10	2,007	32	5.8	.....	
37.....	Pressure..	9	1,967	46	10.7	42,500.....	Initial compression of pressure cylinders 37,500 pounds per square inch.
37.....	Pressure..	8	1,973	26	7.0	42,000.....	Initial compression of pressure cylinders 40,000 pounds per square inch.

Rifleite, for the same initial velocity, gave higher pressures than the Wetteren powder. The uniformity of velocity was inferior to that obtained with the sieved Wetteren and not superior to that of the unsieved Wetteren. On the whole, rifleite seems a fair powder except with regard to the pressure developed, which is too high. Ballistically, it is inferior to Wetteren.

(B) S. R.

This powder is for use in large bore rifles, and was submitted as a suitable smokeless powder for use in the .45 caliber Springfield rifle. The grains are small, irregular in form, and of a pinkish tinge. Different charges were fired for the purpose of determining upon a charge which would give the same velocity as our service charge of black powder without an excessive pressure. In all the tests the service 500-grain bullet and the strong Frankfort Arsenal primer, containing mealed powder, were used. The representative of the Smokeless Powder Company stated that this power should not be compressed, and on account of bulkiness it was found impossible to obtain an instrumental velocity over 1,200 foot-seconds without compression. The results were poor with both compressed and uncompressed charges, the bullets frequently keyholing at 100-foot range and tumbling when fired at the 500-yard range. The pressures developed were about the same as with black powder for corresponding velocities. A charge of 28 grains of S. R. powder gave an instrumental velocity of 1,211 foot-seconds. With the carbine the results were more satisfactory, 25 grains of S. R. powder developing no higher pressure than the service charge of 54 grains, and giving a slightly greater velocity. The uniformity of velocity was satisfactory, and no bullets keyholed or tumbled. It is claimed that the recoil when S. R. powder is used is appreciably less than with a charge of black powder giving the same initial velocity, but a trial in the carbine with cartridges identically the same except as to the charge, one loaded with S. R. powder and one with the ordinary black powder giving the same velocity, failed to confirm the claim.*

S. R. powder was shown to be unsuitable for use in the .45 caliber Springfield rifle cartridge, though it appears to be well adapted for use in the carbine cartridge. If it should be desired to use smokeless powder as a charge for .45 caliber cartridges the powder selected should be suitable for both rifle and carbine cartridges.

(C) S. V.

This powder is for use in revolvers. The granulation is much finer than that of the S. R., and the grains are irregular and of a brown color. A charge of 7½ grains under a compression of .15 inch gave the same instrumental velocity as our service charge of 28 grains of black powder, and compared favorably with it as regards uniformity of velocity. The pressure did not seem to be excessive, judging by the ease of extraction of the cartridge cases. Ballistically, this seems to be an excellent revolver powder, and it has also the advantage of being smokeless and reducing the weight of the cartridge about 20 grains.

(3) B. N. F.

This powder was procured from the Hotchkiss Ordnance Company in the spring of 1892. It is of a light-brown color, and of rather irregular granulation, the powder being produced in sheets and cut up into grains of the size desired.

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* This subject of recoil has been investigated and reported upon separately. See my report of January 24, 1893.

The following results were obtained with a charge of 34 grains, using the 220-grain bullet with German silver jacket:

Rifle.	Number of shots.	Mean velocity 53 feet from muzzle.	Extreme variation.	Mean variation.	Mean pressure per square inch.
		Ft. secs.		*Ft. secs.*	*Pounds.*
Pressure.....	12	1,932	40	10.5	47,000
"J".....	10	1,933	74	13.4	.....

A few shots fired with greater charges gave pressures so high as to be inadmissible. The uniformity of velocity obtained with the 34-grain charge is very fair, but the pressure obtained is too great for the corresponding velocity developed.

(4) *Peyton.*

This powder was manufactured at the California Powder Works, Santa Cruz, Cal., and submitted by Mr. Bernard Peyton in March, 1893. It is of yellowish-brown color, and is produced in the form of cord and divided into grains of the size desired.

Owing to the limited amount of powder furnished, the experiments were necessarily restricted. The following results were obtained:

Rifle.	Powder.	Charge.	Number of shots.	Weight of bullet.	Average initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Mean velocity at 53 feet from muzzle.	Mean variation.
		Grains.		*Grains.*	*Pounds.*	*Pounds.*	*Ft. secs.*	*Ft. secs.*
Pressure....	Wetteren, sieved.	37	10	230	37,500	41,500	1,959	17.0
Pressure....	Peyton	36	12	230	32,500	34,000	1,949	16.0
Pressure....	Peyton	37	6	220	30,000	31,500	2,013	18.5
Pressure....	Wetteren ...	37	9	220	37,500	38,500	1.962	19.6
"T".....	Peyton	39	5	220	39,000	40,000	2,134	15.4

As is shown by the above table, the Peyton powder is decidedly superior, ballistically, to the Wetteren, giving much lower pressures for the same velocity developed.

Improved facilities having been provided for exposing powders to heat, moisture, etc., further tests were made with the following results:

Sample.	Weight of sample exposed.	Time of exposure to moisture.	Gain of weight.	Sample.	Weight of sample exposed.	Time of exposure to heat.	Loss of weight.
	Grams.	*Hours.*	*Per cent.*		*Grams.*	*Hours.*	*Per cent.*
2	15	18	.238	1	15	18	.64

Cartridges were made up from each of the above samples, using a charge of 37 grains with the 220-grain bullet. The results were as follows:

Sample.	Number of shots.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean pressure per square inch.
		Ft. secs.	*Ft. secs.*	*Pounds.*
2.....	6	1,965	26.0	31,500
1.....	6	2,015	18.0	35,000
Charge fired under normal conditions.....	6	2,013	18.5	32,000

In the tests for effect of moisture, a given quantity of powder is exposed for a given time on a sieve over a vessel of water, the whole apparatus being inclosed in a tight box. In the tests for effect of heat, a given quantity of powder is exposed to a certain temperature, 100° to 120° F., for a given time.

With sample 1 the velocity obtained was about the same as with the same charge fired under normal conditions. The pressure was a few thousand pounds greater, but the increase was not marked.

With sample 2 there was a slight loss of velocity, due to the absorption of moisture by the powder, but the loss was not so great as was anticipated. The pressure was about the same as was obtained with the same charge under normal conditions.

The small amount of powder furnished prevented more extended experiments.

(5) *Leonard powders.*

These powders were submitted by Mr. Mason E. Leonard, of Salem, Va. Samples "N" and "J" were tested in March, 1893. The samples were yellow, sample "N" being lighter in color than sample "J." Both were greasy to touch and smell, sample "J" having much the stronger odor, which resembles that of salve. A white substance was apparent in some of the grains, as if the incorporation was not thorough. The grains were fairly regular and of cylindrical form, as if cut to size from cord.

The following results were obtained:

Sample.	Charge.	Number of shots.	Weight of bullet used.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure indicated per square inch.	Remarks.
	Grains.		*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
"J"	33	8	220	2,057	29	35,000	37,000	Two hang fires.
"J"	32	2	220	1,990	6	34,000	35,000	
"J"	34	1	220	2,120	.....	38,000	40,000	
"N" ...	33	5	220	2,118	18	35,000	42,000	
"N" ...	32	2	220	2,124	31	34,000	38,000	

The small amount of powder furnished prevented more extended experiments.

In April, 1893, Mr. Leonard submitted other samples, as follows: Samples "J," "N," and certain special powders, the two former being submitted for extended test and the latter merely to be subjected to a preliminary test for pressure and velocity.

SAMPLE "J."

Mr. Leonard stated that this lot differed slightly in composition from that previously reported upon.

The following results were obtained:

Number of shots.	Charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
5	32	220	2,091	9.4	32,000	38,000	Four hang fires.
6	31	220	2,019	13.8	32,000	33,500	Do.

Twenty grams of this powder were exposed to a temperature of 110° F. for 18 hours; loss of weight, 0.2 per cent; the amount exposed to moisture for same period showed a gain of 2.79 per cent.

Cartridges made up from above lots all missed fire, except one loaded with powder exposed to heat. Further experiments were therefore postponed until a stronger primer could be developed.

This powder did not load properly in the present loading machine, but was loaded without difficulty by hand. In May, 1893, the experiments were resumed, using a stronger primer with the following results, no misfires or hang fires occurring:

Number of shots.	Gun.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
15	"T"	31	220	2,067	14.6	.....	.....	Charge exposed to normal conditions of temperature.
8	Pressure.	31	220	1,977	18	30,000	38,000	Exposed to heat of 120° F. for 24 hours.
8	...do	31	220	1,893	30	26,000	29,000	Exposed to moisture for 24 hours.

The powder exposed to heat showed no gain of velocity, but an increase of pressure of several thousand pounds per square inch, and that exposed to moisture showed a mean velocity less by 100 feet than the normal and a pressure several thousand pounds less than the normal. The uniformity of velocity is inferior to that of the powder in its normal condition.

SAMPLE "N."

Mr. Leonard stated that the composition of the second lot of sample "N" was the same as that of the one previously furnished, but the tests showed superior results for the second lot.

Rifle.	Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*
Pressure	6	30	220	1,880	17.0	32,000	Under 32,000
Do	5	31	220	1,906	6.0	32,000	Under 32,000
Do	5	32	220	1,991	22.0	32,000	Under 32,000
Do	7	33	220	2,037	10.2	31,500	32,500
"T"	10	33	220	2,007	6.3	.....	

Twenty grams of the powder were exposed to a temperature of 110° F. for 18 hours, and 20 grams were exposed to moisture for the same length of time. Loss of weight in first case, 0.44 per cent: gain of weight, 2.69 per cent. Charges were made up from the two lots and fired with the following results in the pressure rifle:

Lot of powder.	Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
Exposed to heat ..	18	33	220	2,008	10.5	30,000	33,000	One misfire.
Exposed to moisture.	8	33	220	1,924	20.0	No compression.	30,000	One hang fire; four misfires.

On account of the misfires and hang fires obtained the experiments were suspended until a stronger primer could be manufactured.

In May, 1893, the tests were resumed with the following results, using a stronger primer: Two lots of cartridges, 1 and 2, were loaded. Lot 1 was kept in the proof house at the ordinary temperature. Lot 2 was exposed for nine days to a temperature of 120° F. The two lots were fired on May 10, with the following result:

Lot.	Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*
1	20	33	220	1,991	12.1
2	20	33	220	1,979	8.2

From the above it appears that the velocity (and presumably the pressure) of the cartridges was not increased by their exposure to high temperatures and that the uniformity of velocity was not affected. The tests for moisture and heat were repeated with the following result, using the pressure rifle:

Lot of powder.	Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*
Exposed to moisture	9	33	220	1,872	37.0	26,000	27,000
Exposed to heat	9	33	220	2,029	19.3	30,000	38,000

With the lot exposed to moisture a falling off of 100 feet in velocity and 5,000 pounds per square inch in pressure is shown, with a great falling off in uniformity of velocity. With the lot exposed to heat the mean velocity is slightly greater than normal, while the pressure is increased by 6,000 pounds per square inch. It is still, however, quite moderate—almost equal to the normal pressure with 36 grains of Wetteren powder.

SPECIAL POWDERS.

(*A*) *No. 7.*

This sample was of a brown color and rather sticky, resembling the other samples. Mr. Leonard stated that it was made more than two years ago. It was fired with the following results in the pressure rifle:

Number of shots.	Weight of charge.	Weight of bullet.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Mean velocity at 53 feet from muzzle.	Mean variation.
	Grains.	*Grains.*	*Pounds.*	*Pounds.*	*Ft. secs.*	*Ft. secs.*
5	30	220	30,000	70,000	2,213	9.6

(*B*) *13 A.*

This resembled in general appearance samples "J" and "N." Only one shot was fired:

Charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.
Grains.	*Grains.*	*Ft. secs.*	*Pounds.*	*Pounds.*
33	220	2,279	30,000	56,500

(*C*) *United States.*

This powder was granulated in small cylinders of a yellow color. The grain was harder than that of the other samples and more smoke was produced than with the ordinary smokeless powder.

Number of shots.	Weight of charge.	Weight of bullet.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Mean velocity at 53 feet from muzzle.
	Grains.	*Grains.*	*Pounds.*	*Pounds.*	*Ft. secs.*
1.....	30	220	30,000	Under 30,000	1,527
1.....	33	220	30,000	Under 30,000	1,669
1.....	36	220	32,500	Under 32,000	1,784
1.....	39	220	32,500	38,000	1,866
1.....	42	220	30,000	51,000	1,958

The above samples were tested as above at Mr. Leonard's request, there not being a sufficient quantity of any of them for a further test.

Mr. Leonard stated that the composition of the lot of sample "N" submitted in April was the same as that of the lot submitted in March. Yet the former gave results superior to those obtained with the latter, and the same charge—33 grains—gave higher velocities and considerably greater pressures with the latter than with the former. The ballistic results with both the "N" and the "J" powders are excellent, and of the two, sample "N" gives rather the better results.

(*6*) *Du Pont powder.*

This powder was submitted in April, 1893, by Messrs. E. I. Du Pont de Nemours & Company, Wilmington, Del.

The powder is of a reddish-brown color, the grains being very small and the granulation quite regular. Mr. Du Pont, representing the firm, stated that a priming of 2 grains of black powder was necessary to properly ignite his powder; accordingly cartridges were made up with and without this priming.

The following results were obtained:

Number of shots.	Rifle used.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation in velocity.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
10.....	Pressure..	37	220	2,030	9.3	40,000	62,000	Initial compression of cylinders not great enough. Two grains black powder used as priming.
5.....	Pressure..	35	220	1,964	9	39,000	54,000	Two grains black powder used as priming. Initial compression of cylinders not great enough.
6.....	Pressure..	35	220	1,916	29	39,000	50,000	No black powder priming. Three hang fires and 1 misfire. Initial compression of cylinders not great enough.

A charge of 36 grains of Wetteren powder was fired in comparison, with the following result:

Number of shots.	Rifle used.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.
		Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*
5.....	Pressure .	36	220	1,984	13.2	37,000	38,000

This powder gives an excellent uniformity of velocity when fired with a black powder priming, but the pressure is much too high, and ballistically it is inferior to the Wetteren. The use of a black-powder priming could probably be dispensed with with the stronger primers manufactured since the test, if the powder was promising in other respects.

(7) *Axtell powder.*

Three samples of this powder were received from Mr. F. C. Axtell, 326 Fifth avenue, New York City, in April and May, 1893.

The powder somewhat resembles curled hair in appearance. Sample 1 is of a violet color; samples 2 and 3 are nearly white.

SAMPLE 1.

This was fired in the pressure rifle, with the following results obtained:

Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
1.....	3	220	.....	.....	.....	.....	Did not drive bullet out of bore.
1.....	10	220	.....	.....	.....	.....	Velocity too low to record. Pressure not taken.
3.....	20	220	1,512	19	34,000	44,000	
3.....	25	220	1,677	11	34,000	65,000	

Twenty-five grains was the maximum charge that could be made to enter the cartridge case.

SAMPLE 2.

Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*
5.....	20	220	1,350	14	None	Under 30,000
1.....	25	220	1,460	.....	Pressure not taken.	

Twenty-five grains was the maximum charge that could be made to enter the cartridge case.

SAMPLE 3.

Number of shots.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	
1.....	25	220	1,532	10	Pressure not taken.
1.....	25	220	1,512	.....	

Twenty-five grains was the maximum charge that could be made to enter the cartridge case.

As with the greatest charge that could be made to enter the cartridge case the velocities obtained were entirely insufficient, it was thought useless to continue the tests. Better results, as regards velocity, with satisfactory pressures, can be obtained in .30-caliber cartridge cases using ordinary black powder.

Independent of its inferior ballistic results, the Axtell powders are not suitable for military small arms in their present form. Machine loading is impossible and hand loading is too slow; three and one-fourth minutes were required to load the 20-grain charge and nearly five minutes to load the 25-grain charge. With practice, 25 or 30 rounds an hour would probably be the maximum attained.

(8) *Troisdorf powder.*

This powder was purchased abroad and first tested here in October, 1892. It is of a lively black color, glazed, and of quite regular granulations, the powder being cut up into small squares. On its first test it was found that the primers used would not explode it properly, misfires or hang fires occurring at nearly every shot. When the cartridge missed fire, on inspection it was found that the primer had exploded with the effect of merely burning off the glaze from the powder, which then appeared of a whitish color. A stronger primer having been manufactured, the tests were taken up in April and May, 1893, with the following result:

Fired in experimental Springfield rifle "T".

[Charge, 35 grains, 220-grain bullet.]

Date.	Number of shots fired.	Mean velocity at 53 feet from muzzle.	Mean variation.	Extreme variation.
		Ft. secs.	*Ft. secs.*	*Ft. secs.*
May 26	50	1,990	20.0	96
	50	1,899	39.0	160
May 29	50	1,925	34.8	152
	50	1,938	16.3	107

[Charge, 36 grains, 220-grain bullet.]

	10	2,031	16.2	54

The pressures obtained were as follows:

Number of shots fired.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
6.....	35	220	1,905	22.0	31,500	32,500	Initial compression of cylinders not sufficient.
7.....	35	220	1,953	12.6	32,000	34,000	
9.....	35	220	1,917	24.0	32,000	33,000	
10.....	36	220	2,047	16.0	34,000	40,000	

The Troisdorf powder does not give any better uniformity of velocity than the Wetteren, but gives less pressure for the same velocity.

Twenty grams of Troisdorf powder were exposed to a temperature of 120° F. for twenty-four hours and 20 grams were exposed to moisture for the same period. The loss of weight in the first case was 1.29 per cent, and the gain in weight in the second case was 1.64 per cent. Cartridges were made up from the above lots and fired with the following results in the pressure rifle:

Number of shots fired.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean initial compression of pressure cylinders per square inch.	Mean pressure per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	
8.....	36	220	1,934	22.0	32,500	33,500	Exposed to moisture.
8.....	36	220	2,096	12.8	42,000	50,000	Exposed to heat.

The 36-grain charge, under normal conditions, gives a mean velocity, at 53 feet from the muzzle, of 2,047 foot-seconds, and a mean pressure under 41,000 pounds per square inch. Mean variation in velocity about 16 foot-seconds. The charges exposed to moisture showed a mean loss of velocity of over 100 foot-seconds and a pressure reduced by 6,000 pounds per square inch, while the charges exposed to heat showed a gain in velocity of 50 foot-seconds and an increase of pressure of 10,000 pounds per square inch.

(9) *Alters powder.*

This powder was submitted in May, 1893, by Mr. Frank S. Alters, Sweet Home, Ark., who calls it a semi-smokeless powder. It somewhat resembles iron filings in appearance. Its granulation is about that of mealed powder, and the grains vary in color, some being brown and some black. It is unglazed, and contains a large amount of dust. Loading is rather difficult, it being necessary to shake the case freely to settle the powder. The following points of superiority are claimed by the inventor: (1) Very little smoke; (2) about half the noise of black powder; (3) less fouling; (4) with 70 per cent of weight of black powder will give more penetration.

The powder was first tried in the .30-caliber cartridge, several shots being fired for velocity with different charges, using 220-grain bullet. The greatest velocity attained at 53 feet from the muzzle was 1,575 foot-seconds, a charge of 38 grains being used, which was the greatest

amount that could be forced into the shell. In the .45-caliber rifle various charges were tried, with the following results:

Number of shots fired.	Weight of charge.	Weight of bullet.	Mean velocity at 53 feet from muzzle.	Mean variation.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	
5.....	42 Alters powder	500	1,284	18.0	
5.....	43 Alters powder	500	1,303	20.0	
5.....	44 Alters powder	500	1,309	31.0	Maximum charge which could be loaded into cartridge case.
5.....	69 service black powder.	500	1,278	2.2	

The Alters powder is unsuitable for use in the .30-caliber rifle, owing to the insufficient velocity obtained with the maximum charge. In the .45-caliber rifle 42 grains of Alters powder gave the same results as 69 grains of service powder, but the velocity is not uniform, and the slight reduction in weight of charge is more than counterbalanced by the defects of the powder. The noise and the amount of fouling did not appear to be less with the Alters powder; the smoke developed was slightly less, but not enough so to warrant the application of the term semi-smokeless powder. The great amount of dust found in the powder would make it unsuitable for use in its present form.

TESTS TO WHICH SMOKELESS POWDERS SHOULD BE SUBJECTED.

It is proposed in the future to have a uniform system of tests to which all smokeless powders should be subjected. This has not been practicable previously, owing to lack of certain facilities which are now provided and to the very small samples of certain powders submitted for test.

The tests will embrace determination of velocities and pressures, using various charges; effect on pressures and velocities of exposing powder and made-up cartridges to moisture, extreme high and low temperature, and abrupt alternations from high to low temperature, and *vice versa;* effect on powder of alternations from dark to light, etc.; facility of loading on machine.

COMPARISON OF SMOKELESS POWDERS TESTED.

Of the powders tested the Axtell and Alters need not be considered, as they are entirely unsuited to the military service. The other powders gave the following comparative results:

I.—*Velocity and pressure.*

For neighboring velocities the following pressures were developed, the 220-grain bullet being used unless otherwise noted:

Powder.	Number of shots fired.	Charge.	Mean velocity at 53 feet from muzzle.	Mean variation.	Mean pressure per square inch.
		Grains.	*Ft. secs.*	*Ft. secs.*	*Pounds.*
Leonard sample "N"	5	32	1,991	22.0	Under 32,000
	7	33	2,037	10.2	32,500
Leonard sample "J"	6	31	2,019	13.8	33,500
Peyton	6	37	2,013	18.5	31,500
Troisdorf	7	35	1,953	12.6	34,000
Wetteren	9	37	1,962	19.6	38,500
Rifleite	9	39	1,969	21.6	45,500
B. N. F	12	34	1,932	10.5	47,000
Du Pont	5	35	1,964	9.0	54,000

Remarks.—The best ballistic results were given by the Leonard sample "N" and the Peyton powders. The velocities given are the nearest that could be taken. The uniformity of velocity obtained with the Leonard powders was superior to that with the Peyton powder; 230-grain bullet used. With this bullet less velocity and more pressure were developed with Rifleite than when Wetteren powder was used.

II.—*Test for moisture.*

[Powders exposed to moisture for 24 hours.]

Powder.	Loss in velocity.	Pressure reduced per square inch.	Increase in weight of powder.
	Ft. secs.	*Pounds.*	*Per cent.*
Peyton	40	2,000	.64
Leonard sample "N"	100	5,000	3.18
Leonard sample "J"	100	5,000	2.97
Troisdorf	100	7,000	1.64

[Powders exposed to heat for 24 hours.]

Powder.	Gain in velocity.	Pressure increased per square inch.	Loss in weight.
	Ft. secs.	*Pounds.*	*Per cent.*
Peyton	10	4,000	.238
Leonard sample "N"	50	6,000	1.69
Leonard sample "J"	None.	5,000	.246
Troisdorf	50	10,000	1.29

CONCLUSIONS.

The Rifleite, B. N. F., and Du Pont powders are inferior to the others, as they give higher pressures without compensating advantages. The Wetteren, which has been used here more extensively than any other powder, gives very fair results, but the pressure is quite high for the moderate velocity developed.

The irregular granulation often causes considerable variations in velocity.

The Troisdorf gives lower pressures than the Wetteren for the same velocity, and seems to be equal to it in other respects, but requires a very strong primer to ignite it.

The Leonard and Peyton powders give the best results as regards pressures and velocities, the Leonard giving the greater uniformity of velocity, and the Peyton seeming to be less affected by heat and moisture; of the two Leonard samples "N" is thought on the whole to have given the best results.

The foregoing is a summary of Lieut. J. W. Benét's experiments at this arsenal during the fiscal year ended June 30, 1893. This summary has been drawn by him under my directions in accordance with the instructions of the Chief of Ordnance of June 22, 1893.

Very respectfully,

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4589–'93.)

In connection with the subject of smokeless powders and what has been said in regard to their effect upon the recoil of small arms, as investigated by Lieut. Col. Farley at the Frankford Arsenal (see page 27 of this report), the following results are calculated.

The .30-caliber rifle.—Maximum velocity of recoil, 9.6 foot-seconds, and energy of recoil, 10.9 foot-pounds.

The .45-caliber rifle.—Maximum velocity of recoil, 14.08 foot-seconds, and energy of recoil, 27.1 foot-pounds.

These values apply to the case of supposed unrestrained recoil, with respect to which Sébert, after extended experiments with the recoil velocimeter, has established the following formulas:

$$(1)\ p_1V_1 = pV + 3{,}000\pi \qquad (2)\ p_1v_1 = (p + \frac{\pi}{2})v$$

in which v and v_1 represent the velocity of projectile and of piece at any instant of time, V the muzzle velocity of projectile, and V_1 the maximum velocity of piece in recoil, and p, π, and p_1 the weights of projectile, powder charge, and piece, respectively.

Equation (2) shows that up to the time the projectile leaves the muzzle the velocity of recoil is directly proportional to the weight of projectile increased by one-half the weight of the powder charge. The velocity of recoil corresponding to the muzzle velocity of projectile may be derived from that equation, whilst equation (1) serves to determine the maximum velocity of recoil. The coefficient of π (3,000) in equation (1) has been determined empirically for conditions of loading within certain limits, and may require a change of value (probably a reduction) in application to the conditions existing in the .30-caliber rifle. This, however, would not change the form of the expression, from which it is seen that the maximum velocity, and hence the energy of recoil, varies with the weight of powder charge. Applying (1) to the .30 and .45 caliber rifles, with weight of 8.8 pounds for each, and given, 30-caliber rifle, charge 37 grains (smokeless), bullet 220 grains, initial velocity, 2,000 foot-seconds; .45 caliber rifle, charge 70 grains (black), bullet 500 grains, initial velocity, 1,315 foot-seconds, we find the respective maximum velocities and energies of recoil as given above.

R. BIRNIE,
Captain, Ordnance Department, U. S. Army.

ORDNANCE OFFICE, U. S. ARMY,
October 1, 1893.

ADDENDA TO REPORT ON SMOKELESS POWDERS FOR SMALL ARMS, PREPARED BY SECOND LIEUT. ROBERT G. PAXTON, TENTH CAVALRY, UNDER THE DIRECTION OF LIEUT. COL. J. P. FARLEY, ORDNANCE DEPARTMENT.

SMOKELESS POWDER.

About the year 1885 several varieties of smokeless powder appeared, and from these the modern smokeless powder has been gradually developed.

MANUFACTURE.

The explosive substances principally employed are as follows: Nitrocellulose, nitroglycerine, nitrosaccarose, nitrobenzine, nitronapthaline, picric acid, etc.

In connection with one or more of those mentioned certain solvents are used, such as sulphuric ether, ethyl acetate, acetone, etc.; also inert bodies or "restrainers;" camphor, paraffine, stearine, benzine, acetine, vaseline, etc.

The following details of manufacture have been translated and abridged from La Poudre sans Fumèe, by Pouteaux:

While the same variety of black powder can be used with equal facility in small arms of different caliber, it is found that each different caliber requires a different variety of smokeless powder. This influence of the caliber becomes more noticeable in small arms as the caliber is reduced, the weight of the bullet being maintained. Thus a powder gave to the 216-grain bullet fired in the caliber 315 rifle an initial velocity of 2,100 foot-seconds, with a maximum pressure of 34,000 pounds, while the same powder and weight of bullet in the .30-caliber rifle gave the same velocity with a maximum pressure of 45,500 pounds per square inch. We must then have a special proportion of powder for such caliber, depending on the sectional density of the bullet used. The chemical composition of these powders is identical, their bal-

listic qualities depending on the thickness and density of the grain which in turn depend upon the method of compression and formation.

The manufacture of smokeless powder can be divided theoretically into six operations: (1) Preparation of the pyroxyl selected; (2) solution of this pyroxyl by a proper solvent; (3) compression; (4) lamination; (5) cutting; (6) drying.

The preparation of the pyroxyl varies with that selected.

SOLUTION.

The principal precaution to be taken in this operation consists in avoiding the formation of globules which contain undissolved particles.

It is easily seen that the uniformity of the powder depends upon the uniformity of the solution.

The degree of solution varies according to the use for which the powder is destined. Sporting powders require an incomplete solution, while for military powders the degree of solution varies directly with the weight of the projectile and inversely with the caliber of the rifle in which it is to be used.

The gun-cotton should not be plunged into the ether, but the ether should be poured over the gun-cotton, which should be in a finely divided state. The method of procedure is as follows:

The gun-cotton (preferably ground) is spread in a layer of suitable thickness in shallow ebonite vats. These are inclosed in a glass cage into which the ether (or other suitable solvent) is introduced. The gun-cotton dissolves gradually; the introduction of ether is stopped, and the solution is allowed to attain the degree desired.

A current of air at 55° C. is then passed over the gelatinized pyroxyl in order to carry off the vaporized ether, which is condensed in a cold retort. This serves to dry the powder and enables the recovery of a portion of the ether, which can be used again—an important matter, as the cost of production of these powders depends principally upon the solvent.

COMPRESSION AND LAMINATION.

During the evaporation of the ether bubbles are produced, rendering the substance more or less porous in spots, giving a lack of uniformity in the density.

The thickness of the sheet after the evaporation of the ether is far from being uniform, and it is known that thickness plays an important part in the ballistic properties of the powder.

To remove the bubbles and regulate the thickness of the sheet of powder it is subjected to a high compression, maintained for some time. This has further the effect of completing the solution of certain particles incompletely dissolved. The sheet of powder is next passed through a laminator, consisting of two cylinders of polished bronze. The upper cylinder should be so adjusted as to give the sheet a uniform thickness.

The desired thickness is obtained by three or four successive operations to prevent tearing the surfaces of the powder, whose elasticity must in some cases be increased by warming the cylinders.

CUTTING.

The graining operation applied to black powder is unsuitable for the smokeless variety, as the latter is pliant and tough, and can not be broken into fragments by repeated shocks. It is therefore reduced to small particles by suitable cutting machines, or is passed while still in a viscous state, through strainers, forming strings, which when dry are cut to the desired length.

The above methods offer the advantage of giving the entire weight of powder in good grains—an important matter, as the resolution of a wastage of 40 to 50 per cent, such as is obtained in the graining of black powder, would be very expensive if not impossible, owing to the greater difficulty in dissolving the pyroxyl a second time.

DRYING.

The operation of cutting is performed while the sheet retains a portion of the solvent. After being reduced to grains, the powder must be dried. This operation must be carried on slowly at a relatively low temperature, as a too rapid evaporation of the remaining ether would give too great porosity to the powder.

Drying becomes more difficult as the thickness is increased.

With cannon powders, which require a thickness of 0.1 inch or more, it is necessary to form several thin sheets, dry them and compress them into a single sheet by means of a hydraulic press.

Further, the drying must not be complete; that is, a certain percentage of the solvent must be left in the powder. This tends to diminish the pressure developed while the normal velocity is maintained.

It should be noted that the above are general theoretical principles, suited to the preparation of a laboratory sample rather than to commercial manufacture.

In the latter case the greatest difficulty consists in the construction of machines capable of giving a uniform and homogeneous product without depending to a great extent upon the skill of the workman.

In the laboratory samples can be prepared that give satisfactory results, but we can never be sure of exactly reproducing them. Often while employing the same methods and using products that are apparently exactly the same we obtain samples of powder that give absolutely different results.

The above is the method of manufacture in general terms.

To throw further light upon the subject, additional details of manufacture will be given under Cordite and other varieties.

American Smokeless Powders.

LEONARD SAMPLE "N."

This powder is formed in strings, like the cordite, but is cut into grains whose length is about equal to two diameters.

The grains are quite uniform; color of first samples, light yellow; later samples, dark purple.

COMPOSITION.

Nitrocellulose (gun-cotton) and nitroglycerine, with an organic substance of vegetable origin, as a restrainer.

These ingredients in the proper proportions are placed in a vat and dissolved in acetone, the subsequent operations being similar to those employed in the manufacture of cordite.

BALLISTICS.

The powder cavity in the service cartridge holds, without compression, 44 grains, giving density of loading =0.84.

A charge of 33 grains imparted a velocity of about 2,100 foot-seconds to the 220-grain bullet, with a wall pressure of about 35,000 pounds per square inch.

The variation in velocity was somewhat less than that given by the Wetteren, while the pressure was some 5,000 pounds per square inch less.

LEONARD "N," FINE GRAIN.

A second sample of the above powder, claimed to have been made by machinery, has been more extensively tested with regard to its ballistic qualities.

A finer granulation gives an increased gravimetric density, the service cartridge holding 48 grains, giving a density of loading =0.92.

The results are as follows, a mean of 20 shots being taken with each charge:

Charge.	Velocity at 53 feet.	Muzzle velocity.	Pressure per square inch.	Variation.	
				Mean.	Extreme.
Grains.	*Ft. secs.*	*Ft. secs.*	*Pounds.*		
33.....	2,011	2,055.0	31,000	10.9	49
35.....	2,090	2,135.6	35,000	10.4	54
37.....	2,145	2,191.7	39,500	11.2	48
39.....	2,243	2,291.2	41,500	10.2	46

This shows lower pressure for the velocity imparted, and greater uniformity than is given by any foreign powder tested.

In rapid firing the heat developed is considerable. After rapidly firing 10 shots in the Springfield experimental rifle the barrel was found to be quite hot. After 20 shots the wooden hand guard in front of the rear sight was uncomfortably hot, and after 30 shots the sight itself was so hot that it could not be accurately adjusted with the ungloved hand.

The grains are rather soft and elastic and have a gummy appearance. While this will be an advantage in preventing trituration of the grains by friction in the cases, it will probably prevent machine loading.

The fouling is slight, the smoke faint and quickly dissipated, and no injurious effect upon the bore of the gun has been developed.

The climatic stability of the powder and the effect of heat and moisture remain to be ascertained.

Excellent results are claimed for certain varieties of Leonard powder in the Brown segmental wire-wound (5-inch) gun.

Peyton Smokeless Powder.

This powder in appearance is quite similar to the Leonard, the grain being slightly harder, indicating possibly a greater per cent of gun-cotton.

The results of limited tests indicate ballistic qualities similar to those given by the Leonard smokeless.

Axtellite Smokeless Powder.

Resembles curled hair in form, white or bright-violet color. Composition, secret.

Ballistics.—Charge, 25 grains; velocity, 1,677 foot-seconds; mean variation, 8 foot-seconds; pressure, 66,000.

The above is the maximum amount that can be gotten into the shell. Machine loading is impossible and hand loading slow.

(3) P. P. G.

A powder invented and tested by Lieut. W. Walke, Fifth Artillery.

COMPOSITION.

Contains nitrocellulose and nitroglycerine; the nitrocellulose is not gun-cotton, but a specially prepared compound. It is said to contain considerably less nitroglycerine than the Leonard powder.

BALLISTICS.

With the Springfield experimental rifle, caliber .30, and the 230-grain bullet, the following record of velocity and pressure was obtained:

Charge.	Velocity.	Pressure per square inch.
Grains.	*Ft. secs.*	*Pounds.*
38	2,026.25	31,775
40	2,216.25	33,517
42	2,367.50	35,325

The above record is given by Lieut. Walke, and great uniformity in velocity and pressure is claimed for the powder; also good climatic stability and keeping qualities.

The following is the composition of certain smokeless powders adapted to sporting purposes:

SCHULTZE.

Nearly spherical grains of a whitish color.

Composition (Munroe).

Nitro-cotton	27.71	Barium nitrate	27.62
Gun-cotton	32.66	Sodium nitrate	2.88
Cellulose	1.63	Potassium nitrate	2.47
Paraffine	4.20	Volatile	1.48

AMERICAN WOOD POWDER.

Consists of dark brown rounded grains.

Composition (Munroe).

Soluble nitrolignine	29.25
Insoluble nitrolignine	14.06
Lignine (charred)	28.08
Humus	10.32
Sodium nitrate	15.27
Volatile	3.01

ENGLISH SMOKELESS POWDERS.

CORDITE.

Composition.

Gun-cotton	37
Nitroglycerine	58
Vaseline	5

NOTE.—"Vaseline" is a liquid which distills over from petroleum at temperatures above 200 C. Formula, $C_{16}H_{34}$. "Acetone" is produced from the distillation of wood. Formula, CH_3COCH_3.

MANUFACTURE.

A portion (27¾ pounds) of gun-cotton, dried to about 1 per cent moisture, is placed in a brass-lined box, and 43½ pounds nitroglycerine carefully poured over it. The ingredients are then mixed by hand and

taken to the incorporating machines, and the whole is brought to a gelatinous condition by the addition of about $15\frac{10}{16}$ pounds of acetone, which is poured over the charge in the incorporating machine and worked up into a kind of dough.

Three and three-fourths pounds vaseline is afterwards added and the material is incorporated or mixed for seven hours. When it has been sufficiently incorporated the charge is taken to the press-house, where it is squeezed into a cylinder, one end of which has a small hole of the required size for the cordite, which is squirted through by means of a piston pressing on the other end of the cylinder, the material coming out in the form of a cord or string of the size required.

The sizes vary from 0.0375 inch, for the rifle, up to 0.5 inch, which has been used in a heavy breech-loading gun with satisfactory results.

The string is wound on reels for the smaller or cut into lengths for the larger natures; it is then placed in a stove and is dried to get rid of the acetone, at 100 F., from three to nine days, according to thickness.

It is afterward blended in the rifle cordite by taking the production of ten presses which are on "one-strand reels" and winding these on to one "ten-strand reel." Then the cordite on six ten-strand reels is wound on one drum, making a cord of 60 strands, which in short lengths forms the $30\frac{1}{2}$-grain charge for the magazine rifle.

Cordite has proved very safe to manufacture in its later stages, and although great care must be exercised in the earlier stages when dealing with the high explosives, no accidents of any consequence have occurred.

BALLISTIC QUALITIES.

Comparative results derived from tests of cordite and black powder at Waltham Abbey.

Powder.	Arm.	Charge.	Velocity.	Pressure per square inch.
			Ft. secs.	*Pounds.*
Black	Magazine	70 grains	1,830±40	40,000
Cordite	Rifle	30 grains	2,000±40	33,600
Black	12 pr. B. T	4 pounds	1,710±20	33,600
Cordite	do	1 pound ½ ounce	1,210±20	33,600
Black	4.7″ Q. F	12 pounds	1,830±30	39,400
Cordite	do	5 pounds 7 ounces	2,145±25	33,600
Black	6″ Q. F	29 pounds 12 ounces	1,890	33,600
Cordite	do	14 pounds 3 ounces	2,274	34,000

The above indicates very favorable results both as regards velocity and pressure.

CLIMATIC STABILITY.

The powder has been exposed to Canadian winter and to the summer heat of India with (as it is claimed) no material injury to its shooting qualities.

EFFECT UPON THE WEAPON.

An injurious effect upon the barrel, resulting from the great heat evolved and the high velocity imparted, is claimed to have been practically overcome by the use of a suitable wad.

NOTE.—The above remarks on cordite have been abridged from a lecture by Lieut. Col. Barker, R. A., before the Royal Artillery Institution, January 23, 1893.

RIFLEITE.

Composition (Munroe).

Nitro-cotton	22.48
Gun-cotton	74.16
Phenyl amidoazobenzine	2.52
Graphite	Trace.
Volatile	0.84
Total	100

square flat grains of the color of graphite and the odor of wood spirit which has apparently been used in water-proofing.

This operation is not entirely efficacious, however, as water will remove a portion of the graphite, etc.

Ballistics.

In the .30-caliber rifle, 230-grain bullet, a mean of 30 shots with a 39½-grain charge (density of loading=0.76) gave 1,990 foot seconds velocity at 53 feet from the muzzle, with a mean variation of 20 foot-seconds; extreme variation, 95 foot-seconds; pressure 50,000 pounds per square inch.

Accuracy fair, but slightly inferior to Wetteren.

S. R. POWDER.

Composition (Munroe).

Nitro-cotton	28.18
Gun-cotton	46.97
Auriu (alkaline)	1.06
Barium nitrate	19.97
Potassium nitrate	2.35
Volatile	1.45
Total	99.98

Adapted to the .45-caliber rifle. Greatly inferior to the black powder in uniformity and accuracy. Maximum pressure 2,000 to 4,000 pounds per square inch higher; recoil about 10 per cent less.

BELGIAN SMOKELESS POWDER.

WETTEREN.

Specific gravity, 1.53 (Capt. Pitman).

Powder cavity in service cartridge holds 38 grains without compression, giving density of loading = 0.7288.

BALLISTICS.

Has been extensively tested at Frankford Arsenal, using the Springfield experimental rifle and the 230 and 220 grain bullets.

RESULTS.

A charge of 37 grains, corresponding in the service cartridge to a loading density of 0.7077, will impart to the 220-grain bullet a muzzle velocity of slightly over 2,000 foot-seconds, with a maximum wall pressure of about 38,000 pounds per square inch.

The variation in the velocity imparted by apparently equal charges is considerable (as in all smokeless powders), reaching in some cases over 100 foot-seconds. This, however, does not prevent a very fair accuracy in firing, as is shown by the following, which is a mean of 70 targets of 10 shots each, fired in a heavy nonrecoil barrel, at 500 yards:

	Feet.
Mean radius of circle of shots	0.34
Mean vertical deviation	0.24

A series of 1,000 rounds, fired in the .30-caliber rifle with the 220-grain bullet and 37-grain sieved Wetteren powder, gave the following results:

Mean velocity at 53 feet, 1,993.6 foot-seconds; extreme variation, 106 foot-seconds; mean variation, 18.4 foot-seconds.

For accuracy at 500 yards, mean of 100 targets of 10 shots each:

	Feet.
Mean radius of circle of shots	1.13
Mean vertical deviation	0.95

Extensive tests have been made of the climatic stability of this powder with fairly satisfactory results. Fouling slight, and no injurious effect upon bore has been developed so far.

German Smokeless Powder.

We quote from the report for 1891 of the Cologne United Powder Works (manufacturers of Noble C/89 Germany):

While our Duneberg factory makes smokeless powder on the basis of nitroglycerine and nitrocellulose, our Rothweil factory, as is known, has for years been producing powder from pure nitrocellulose.

It can now be stated certainly that both these kinds of powder will exist together; the one preëminently as musket powder, the other rather as cannon powder.

Only the one sort has particularly attracted the attention of foreign countries, as already shown by more or less extensive orders.

Besides the superior ballistic qualities of this powder, we have this further advantage (which exists for no other competing powder in such large quantity), viz, the fact of good storage endurance, as established by several years of keeping already; an advantage that will prove of value to us with those countries that have not yet finally determined on their choice of powder.

Professor Munroe gives the following analysis of a German powder made for use in the 8-inch B. L. rifle.

It is composed of cubical grains, 1 cubic centimeter in volume, the surfaces being covered with graphite composition:

Nitro-cotton	48.83
Gun cotton	7.45
Nitroglycerine	43.15
Graphite	Trace.
Volatile	0.53

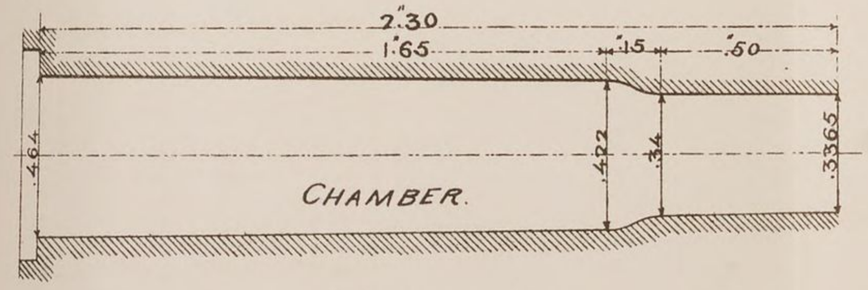
Troisdorf Powder.

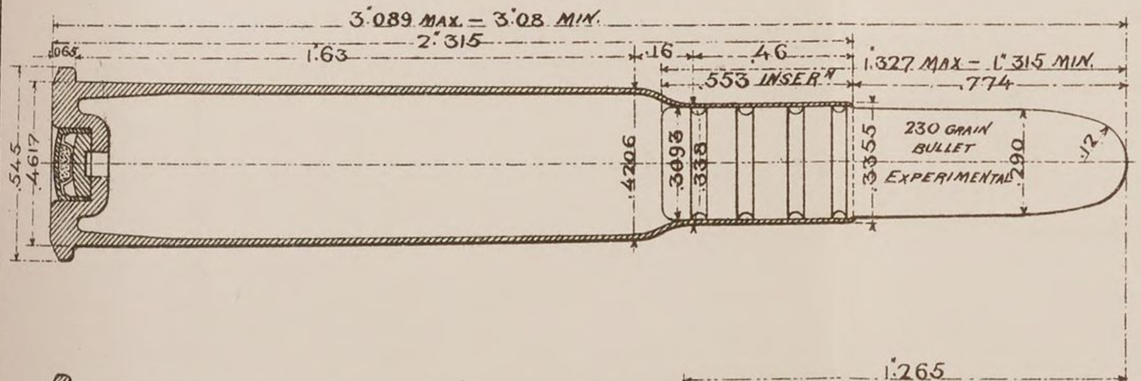
Similar to Wetteren in appearance, and not differing materially in ballistic qualities, stability, etc.

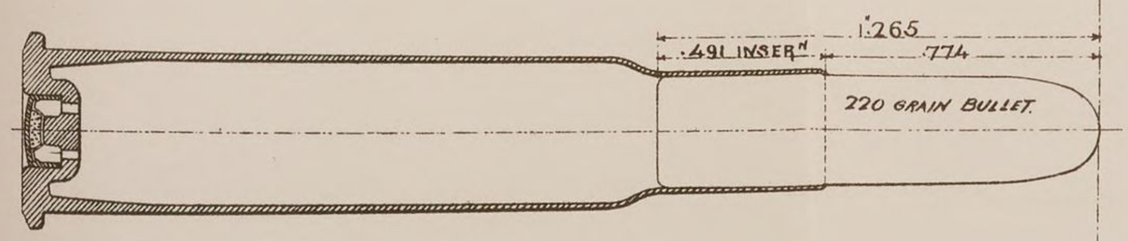
This powder has been found difficult to ignite with the ordinary primer, but this difficulty can be overcome by the use of a special primer.

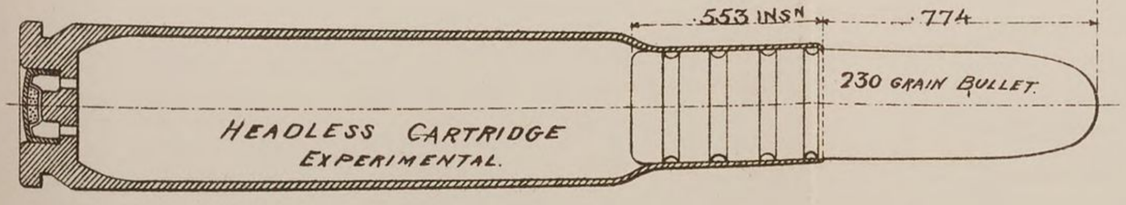
It appears, like the Wetteren, to have considerable climatic stability, but evolves considerably more heat than the latter.

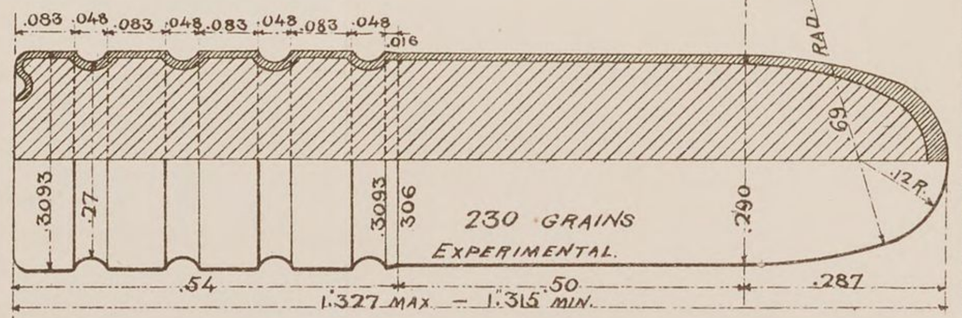
30 CAL. RIFLE CHAMBER, CARTRIDGES AND BULLETS.

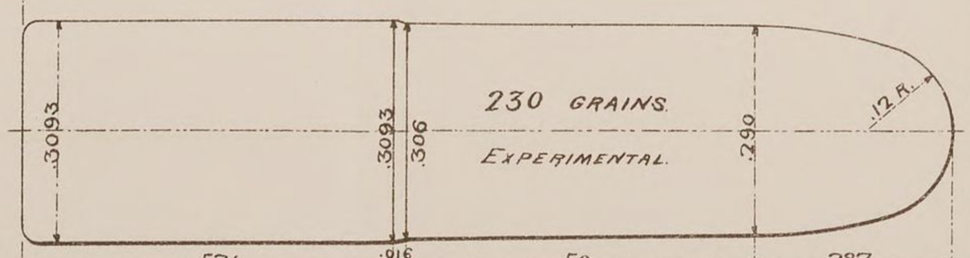


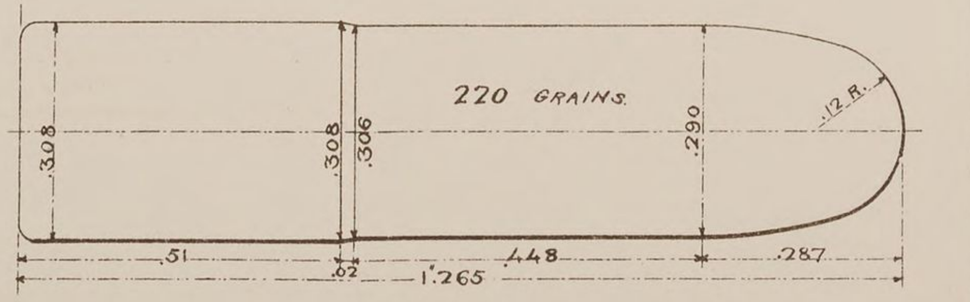




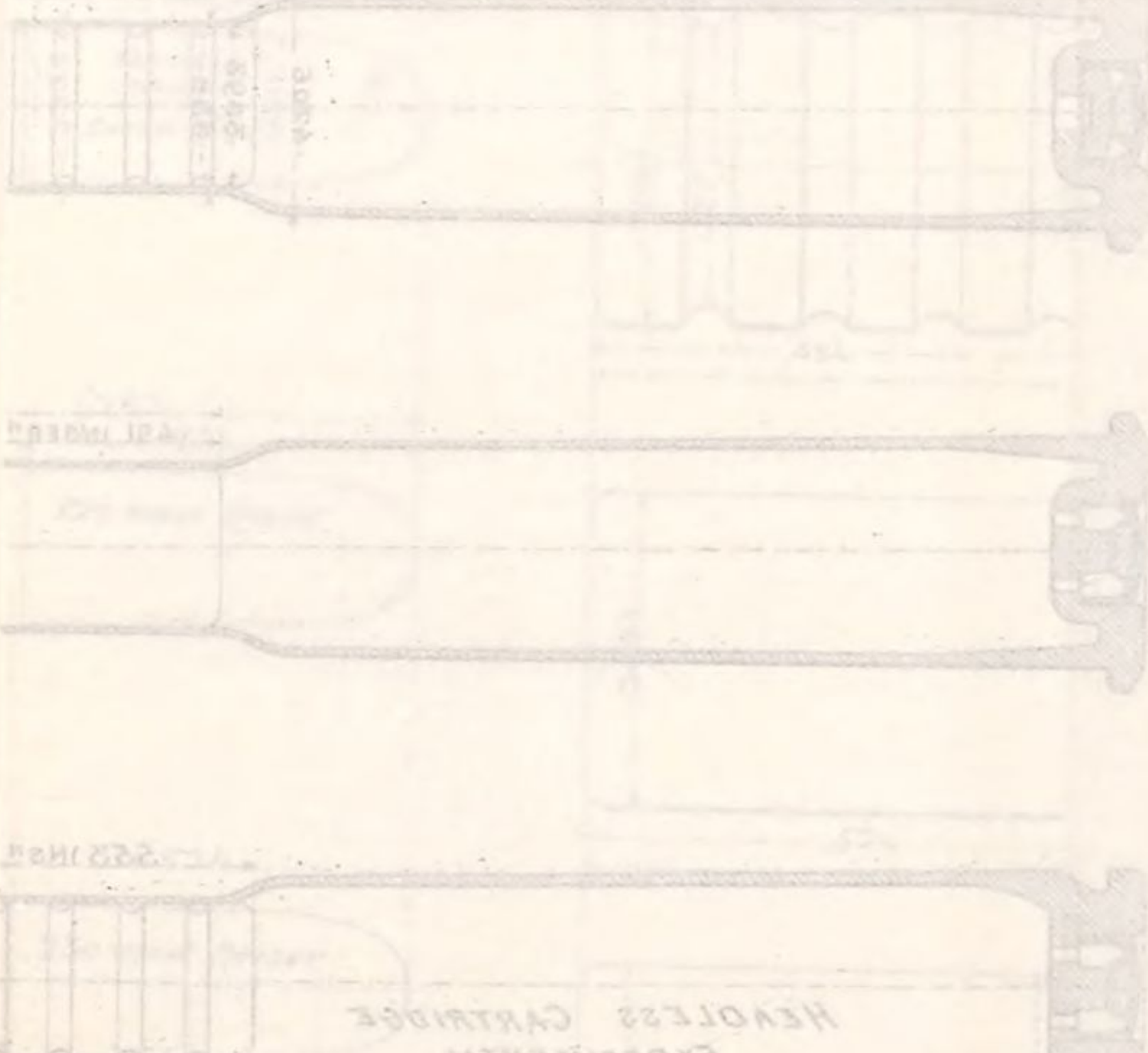


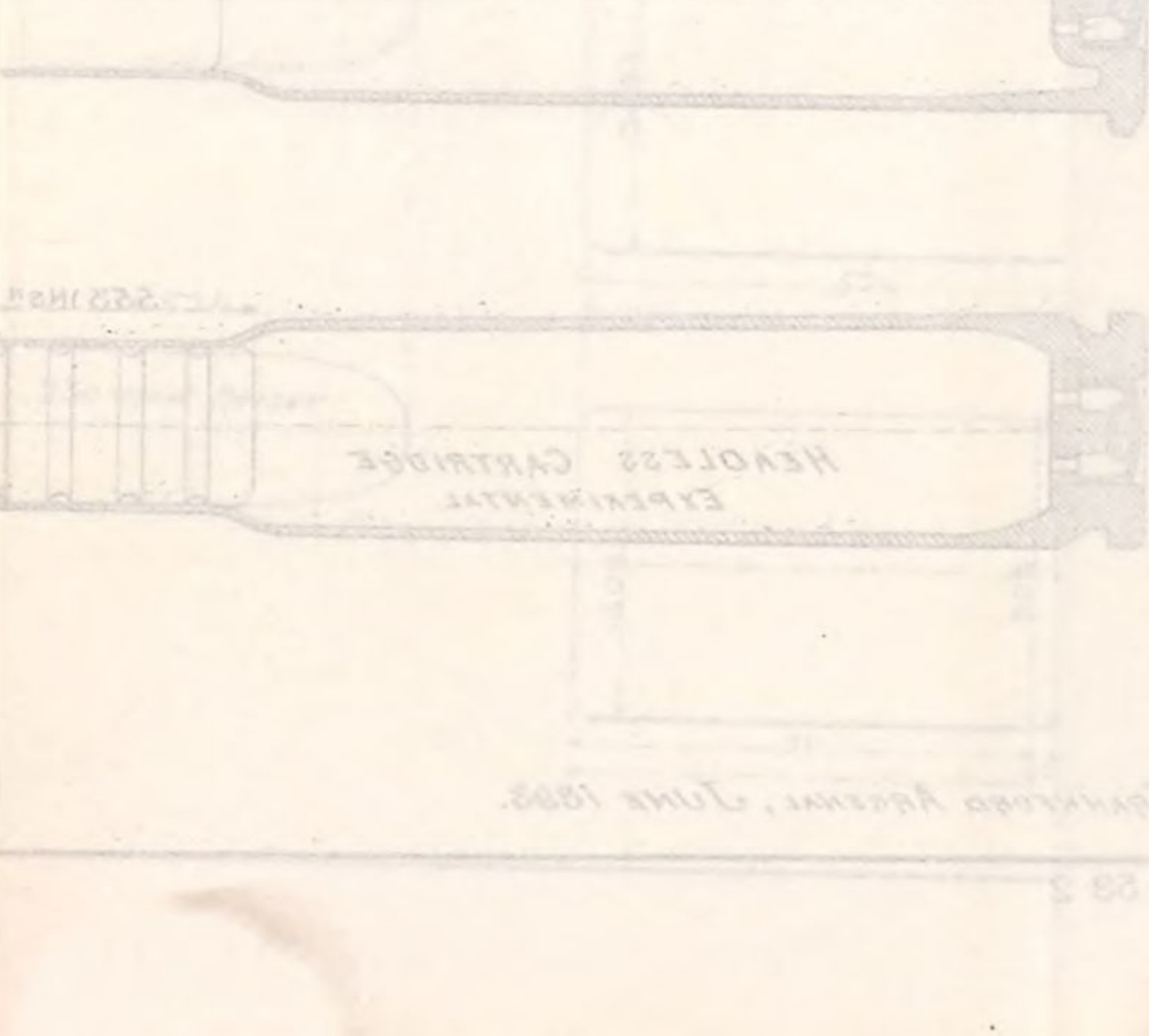






FRANKFORD ARSENAL, JUNE 1893.





APPENDIX 15.

PROGRESS REPORT ON THE MANUFACTURE OF .30-CALIBER AMMUNITION, AT THE FRANKFORD ARSENAL, PENNSYLVANIA, BY LIEUT. COL. J. P. FARLEY, COMMANDING.

(2 plates.)

[See Plate I, Appendix 14, for drawing of cartridges and bullets.]

FRANKFORD ARSENAL,
Philadelphia, Pa., June 30, 1893.

SIR: In obedience to your instructions, I have the honor to respectfully forward a condensed report of progress made in the manufacture of .30-caliber ammunition (more especially bullets and primers) during the last fiscal year.

The present plant for the production of the new caliber .30 rifle ammunition consists of old machines, modified to accord with the changed conditions of manufacture. An output of 16,000 cartridges a day may confidently be relied upon. It is proposed to gradually substitute new machines, procured by manufacture or purchase, thus lessening cost and increasing amount of product.

The following modifications have been made in the components of the cartridge, in accordance with the recommendations of the caliber board, approved by the Chief of Ordnance, and as the result of experiment:

CASE.

The exterior dimensions have not been changed, but the slightly decreased diameter of the bullet has necessitated a thickening of the neck of the case.

BULLET.

(A) DIMENSIONS AND WEIGHT.

The weight of the bullet has been reduced from 230 to 220 grains, in accordance with the recommendation of the caliber board, and its diameter has been reduced from .309 inch to .308 inch, to better adapt it to the rifling adopted for the new rifle. The length of cartridge not being changed, this reduction of weight and consequent shortening of the bullet increases the powder space in the cartridge case. The cannelures have been omitted, in accordance with the recommendation of the caliber board.

(B) COMPOSITION.

The alloy of which the bullet is made has been fixed for the present at 12½ per cent of tin and 87½ per cent of lead.

(c) JACKET METAL.

German silver continues to be the jacket metal used. Certain lots of metal furnished by contractors have had to be rejected on account of failure in firing test, and rigid working tests as well as firing tests have been established for future deliveries.

Nickeled steel jackets furnished by Hermann Boker & Company, New York, have been tested and found to be decidedly superior to the German-silver jackets as regards penetration and resistance to deformation.

The following tables give the comparative penetrations in sand and oak of the .45-caliber bullet and .30-caliber bullet, with different varieties of jacket:

TABLE I.—*Penetration in sand.*

[Charge, 37 grains Wetteren powder.]

Kind of jacket.	Penetration.	Remarks.
	Inches.	
1. Copper	8	Badly deformed.
2. German silver	8	Do.
3. Cupro-nickeled steel	14	Not deformed.

TABLE II.—*Penetration in hard oak.*

No. of shot.	Distance fired at.	Caliber of rifle.	Powder charge.	Bullet.	Target, kind of wood.	Penetration.	Remarks.
	Feet.	*Inch.*	*Grains.*	*Grains.*		*Inches.*	
1	50	.45	Black powder, 69..	500 lead	Oak, not well seasoned	3.2	Bullet badly deformed; fired against the grain.
2	50	.30	Wetteren, 37	220 German silver jacket	do	5.3	Do.
3	3	.30	Wetteren, 37	do	do	5.3	Do.
4	3	.30	Wetteren, 37	do	do	5.3	Do.
5	3	.45	Black powder, 69 .	500 lead	do	3.3	Do.
6	3	.30	Wetteren, 37	220 cupro-nickeled steel jacket	do	19.5	Bullet not deformed; fired against the grain.
7	3	.30	Wetteren, 37	do	do	18.5	Bullet not deformed; bullet penetrated knot in wood; fired against the grain.
8	3	.30	Wetteren, 37	230 copper jacket	do	4.0	Bullet badly deformed; fired against the grain.
9	3	.30	Wetteren, 37	220 German silver jacket	do	5.0	Do.
10	3	.30	Wetteren, 37	do	Dry oak, well seasoned	4.5	Do.
11	3	.30	Wetteren, 37	220 cupro-nickeled steel jacket	do	16.5	Bullet not deformed; fired against the grain.
12	3	.30	Wetteren, 37	230 copper jacket	do	6.7	Bullet badly deformed; fired with the grain.
13	3	.30	Wetteren, 37	220 German silver jacket	do	7.0	Do.
14	3	.30	Wetteren, 37	220 cupro-nickeled steel jacket	do	24.2	Bullet not deformed; fired with the grain.

The comparative penetrations of the different bullets in oak is shown in Plate I.

Twenty thousand jackets have been purchased, as well as a quantity of the metal. By making the latter into jackets any difficulties to be overcome in manufacture will be developed. Further experiments will be carried on, embracing comparative penetrations of bullets, using various jacket materials in different kinds of wood, metal, earth, etc. The comparative accuracy of these bullets will also be thoroughly investigated.

The material used for the nickeled steel jackets is stated to be "steel sheets plated on both sides with nickel copper." It is understood that a sheet of steel is placed between two sheets of cupro-nickel and the three sheets compacted into one by rolling, the details of this operation not being known. The thickness of the jacket is about the same as that of the German silver one used here, except at the point, where the metal is considerably thicker. It is probable from the results already obtained that this nickeled steel will be found more suitable than German silver for bullet jackets.

LUBRICANT.

The lubricant has been omitted in accordance with the recommendation of the caliber board.

Experiments were made during the year to determine the effect of cannelure lubrication upon the accuracy and velocity of small caliber bullets and wear of bore. Two new experimental .30-caliber Springfield rifles were used, one being used exclusively with lubricated ammunition and the other exclusively with nonlubricated. Both rifles were as carefully star-gauged before firing as the gauge would permit. The charge employed was 37 grains of sieved Wetteren smokeless powder. The bullet used was lead alloyed with tin, with German silver jacket, cannelured to hold the lubricant in the case of the lubricated ammunition, uncannelured with the nonlubricated ammunition. An equal number of shots was fired for velocity and accuracy from each gun. The velocity records were made in series of 50 shots, and the accuracy was determined by firing 5 targets of 10 shots each for a series. The results are given in the following tables:

Velocity at 53 feet from muzzle.

[Series of 50 shots each.]

No. of series.	Mean velocity.		Mean variation.		Extreme variation.	
	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.
	Ft. secs.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
1	1,982.10	1,973.20	18.0	20.84	70	125
2	1,974.90	1,978.12	17.30	18.30	82	108
3	1,974.16	1,978.32	16.58	20.24	106	93
4	1,952.10	1,951.60	21.38	20.88	106	122
5	1,950.30	1,970.50	16.84	16.60	110	81
6	1,959.24	1,966.18	19.90	20.42	122	112
7	1,964.50	1,956.50	15.40	25.98	74	128
8	1,966.50	1,968.40	16.92	20.60	78	95
9	1,957.16	1,966.02	15.52	17.26	74	98
10	1,983.72	1,972.52	16.82	21.88	80	79
Mean of 500 rounds	1,966.45	1,968.13	16.4	20.3	.....	.....

	Lubricated ammunition.	Nonlubricated ammunition.
	Ft. secs.	*Ft. secs.*
Greatest velocity obtained	2,037	2,033
Least velocity obtained	1,900	1,896
Extreme variation	137	137

Accuracy at 500 yards.

[Series of 5 targets of 10 shots each.]

Number of series.	Mean radius circle of shots.		Mean vertical deviation.	
	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1	1.214	1.194	1.044	1.008
2	0.880	1.008	0.727	0.846
3	1.036	1.066	0.839	0.803
4	1.440	1.232	1.215	0.932
5	1.270	1.230	1.125	0.967
6	1.146	1.146	0.895	0.914
7	1.212	1.156	0.871	0.764
8	1.378	1.402	1.210	1.180
9	1.406	1.386	1.288	1.104
10	1.336	1.484	1.234	1.333
Mean of 50 targets of 10 shots each	1.231	1.230	1.04	0.98
Best target of 10 shots	0.60	0.73	0.46	0.55
Worst target of 10 shots	1.89	2.04	1.73	1.83

From the above tables it appears that the cannelured and lubricated bullets give no increase of velocity, though the mean variation with these was less in the trials than with the other variety, and that there is no difference as to accuracy between the two kinds of ammunition. The .30-caliber targets given above are far inferior to those ordinarily obtained with the .45-caliber rifle. This is due, however, not to the inferiority in accuracy of the .30-caliber ammunition, but probably to the variation of the rifle barrel confined in the fixed rest used. A heavy .30-caliber rifle barrel, made specially for the purpose, was substituted for the ordinary barrel, and remarkable accuracy was obtained with the same ammunition; accuracy superior to anything ever before recorded here. It is thought that when the service .30-caliber rifle is fired from the shoulder the targets will be better than when a fixed rest is used, as the barrel in the former case is not abnormally restrained. The rifles used were gauged after the above experiments, and their bores seemed, if the gauge is to be trusted, to be unaffected by the number of rounds fired (1,036 rounds each).

It is proposed to fire another 1,000 rounds from each of these guns, and the experiment is now nearing completion, having been frequently interrupted by other more pressing work.

PRIMER.

The primer mentioned on page 191, Report of Chief of Ordnance, 1890, which was devised as a substitute for the service primer when the latter failed to work satisfactorily with some of the first smokeless powders tested, has been used in all cartridges loaded with Wetteren powder, and has given satisfactory results. With some other smokeless powders, notably the Troisdorf, this primer was found wanting in strength, frequent misfires and hang fires occurring. On examining the cartridges which missed fire, it was found that the primer had exploded in every case with the effect of merely burning off the glazing of the powder without producing combustion of the grains. It became necessary therefore to devise a stronger primer, and extensive experiments were carried on, using different primer compositions, vents of different sizes, and anvils fixed and movable, the latter being of two different designs. The anvils and vents tried are shown in Pl. II. They are, first, the service anvil and vent. Second. A modified anvil with enlarged opening

to favor the spread of the flame, and by producing more favorable conditions as to the reaction upon the primer to diminish the chance of blowing it out. This anvil is used with a pierced vent 0.05 inch in diameter, it being thought that the reduction in diameter from 0.07 inch to 0.05 inch would increase the intensity of the flame transmitted from the primer composition. Third. A solid anvil like that in the Mauser cartridge, having 2 vents 0.03 inch in diameter.

The service anvil and vent showed its inferiority early, and was dropped in order to avoid the complication of too numerous combinations of anvil, primer composition, and weight of primer pellet. The solid anvil showed a slight inferiority to the modified one with reduced vent as regards misfires and hang fires. It is also more difficult to manufacture. The velocity or uniformity of velocity did not seem to be affected by the kind of anvil or vent.

Seven different kinds of compositions were tried, the weight of pellet used being first about 0.25 grain and afterwards 0.40 grain. Varying results were obtained with different compositions, but misfires occurred with most and hang fires with all in a very limited number of shots, using the 0.25 grain pellet. With the 0.40 grain pellet four of the compositions gave excellent results, the average of hang fires being a fraction of 1 per cent, and those occurring being hardly noticeable to the ear. No cartridges missed fire with the above primers, though over 500 shots were fired. These results, so far as they go, indicate that increasing the amount of composition in the primer produces the proper ignition of a smokeless powder, while varying the proportion and kinds of ingredients of composition has less effect. Abroad, so far as known, the amount of primer composition has been increased for smokeless powders.

With the Troisdorf powder, which was used in all of the above tests, it was not found that the pressure or velocity obtained was affected by the substitution of one primer for another having a different composition. Nor did the increase of weight of composition from 0.25 to 0.40 grain seem to affect the pressure or velocity developed. When hang fires took place the velocity generally fell off and the pressure was correspondingly reduced. The 0.40 grain pellet, made up of any of the four following compositions, exploded the Troisdorf powder successfully when the improved anvil and reduced vent were used. The Troisdorf is the most difficult powder to explode yet received here.

Compositions.

[Parts by weight.]

	No. 3.	No. 4.	No. 5.	Regular composition used in 0.45″ caliber primers.
Fulminate of mercury	45.1	46.6	61.3	64
Chlorate of potash	25.8	23.3	19.1	18
Antimony	12.9	10.0	.....	.....
Sulphur	.....	3.3	.....	.....
Glass	16.1	16.6	17.8	18
Mealed powder	.....	.....	1.5	.....

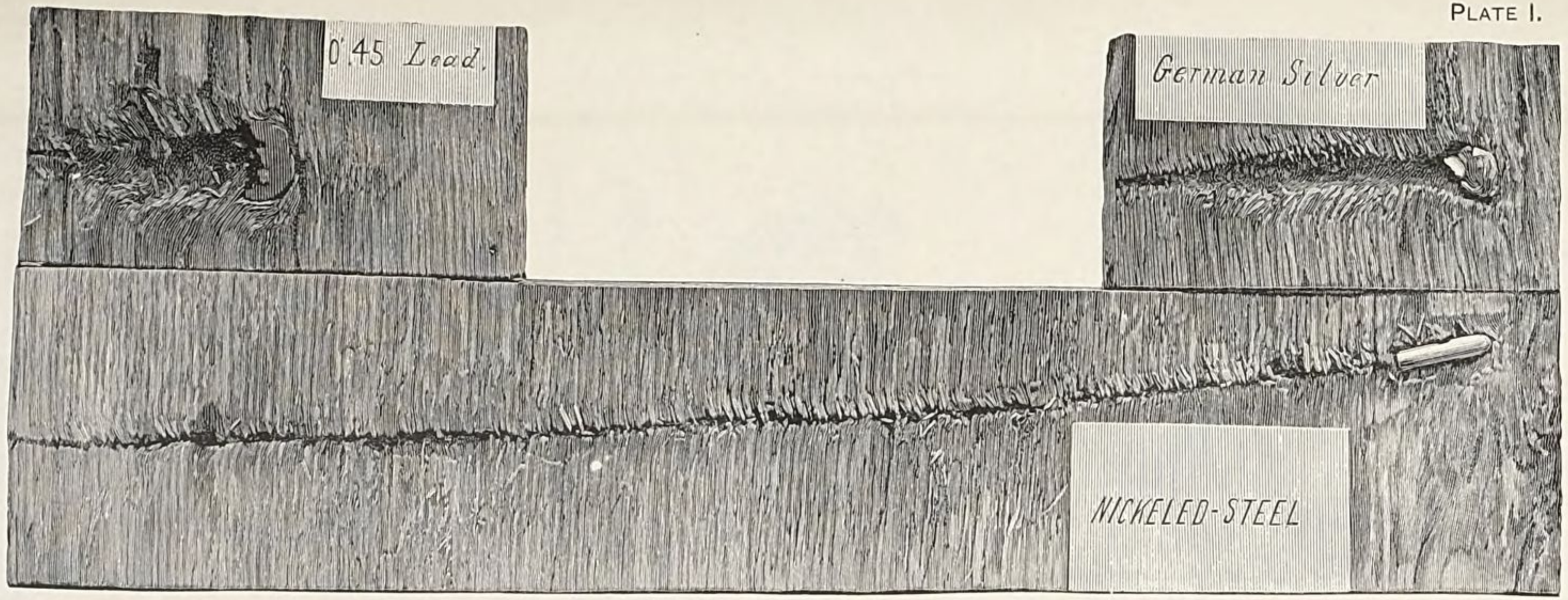
An occasional hang fire resulted in the tests, but the percentage was only a fraction of 1 per cent. It should be stated, by way of qualification, that a second lot of composition No. 3, made up some weeks sub-

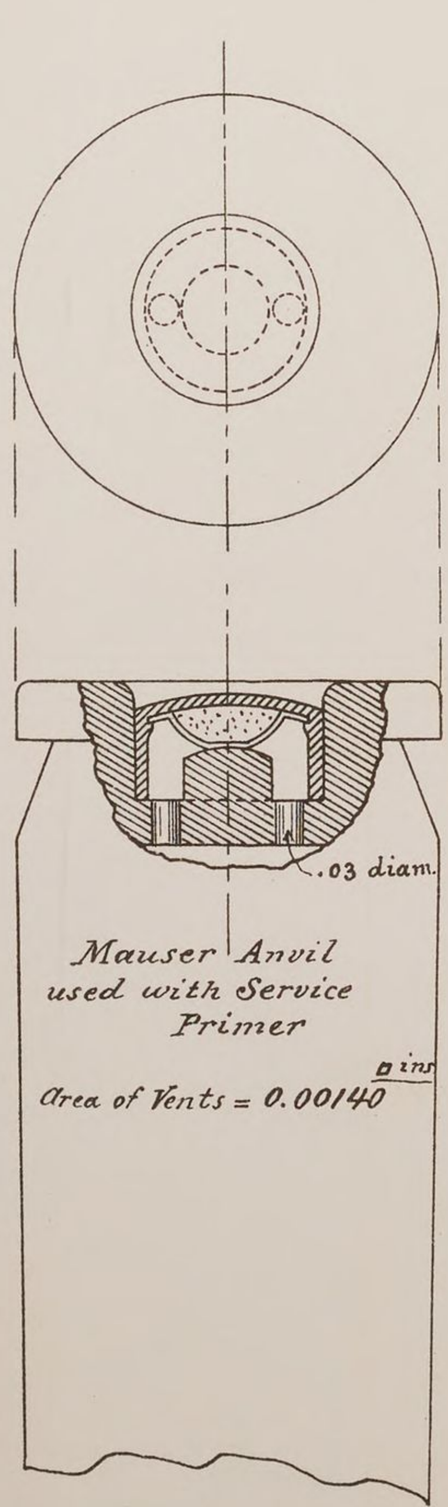
sequent to the first, gave very unsatisfactory results. Primers of the first lot, fired at the same time, gave no failures or hang fires. The failures with the second lot are possibly due to some defect in manufacture, or to some as yet unexplained cause, and, until the matter is more thoroughly investigated, no definite expression of opinion on this subject is warranted.

I am, sir, very respectfully,

J. P. FARLEY,
Lieutenant-Colonel, Ord. Dept., Commanding.

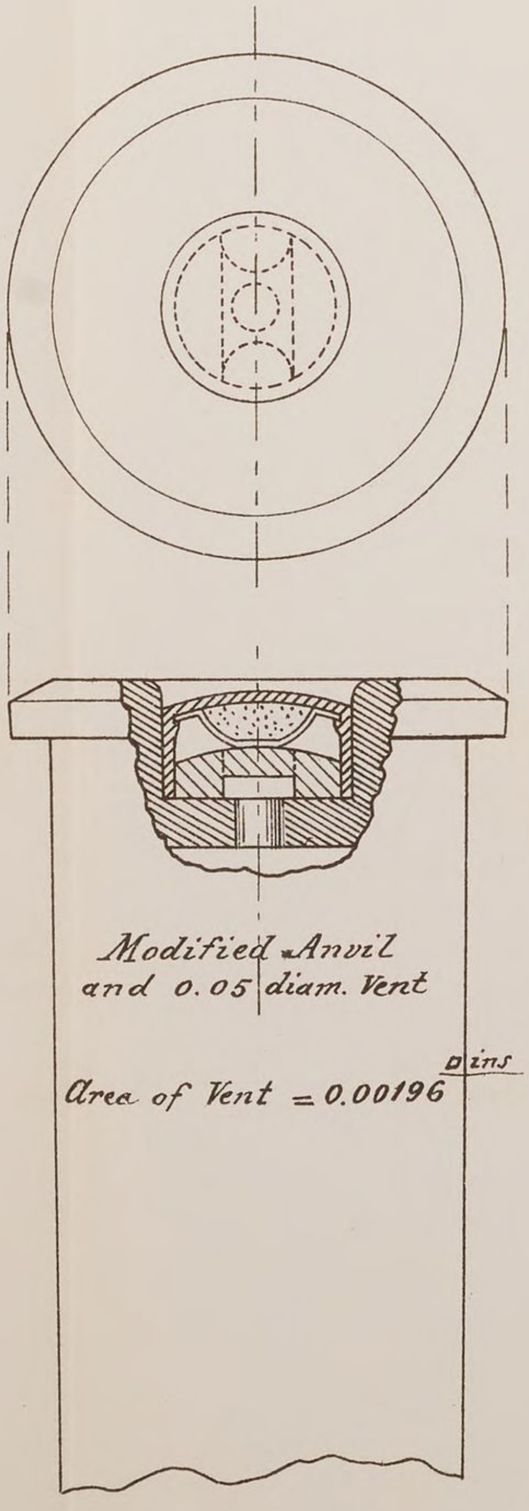
The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.


0·45 Lead.
German Silver
NICKELED-STEEL



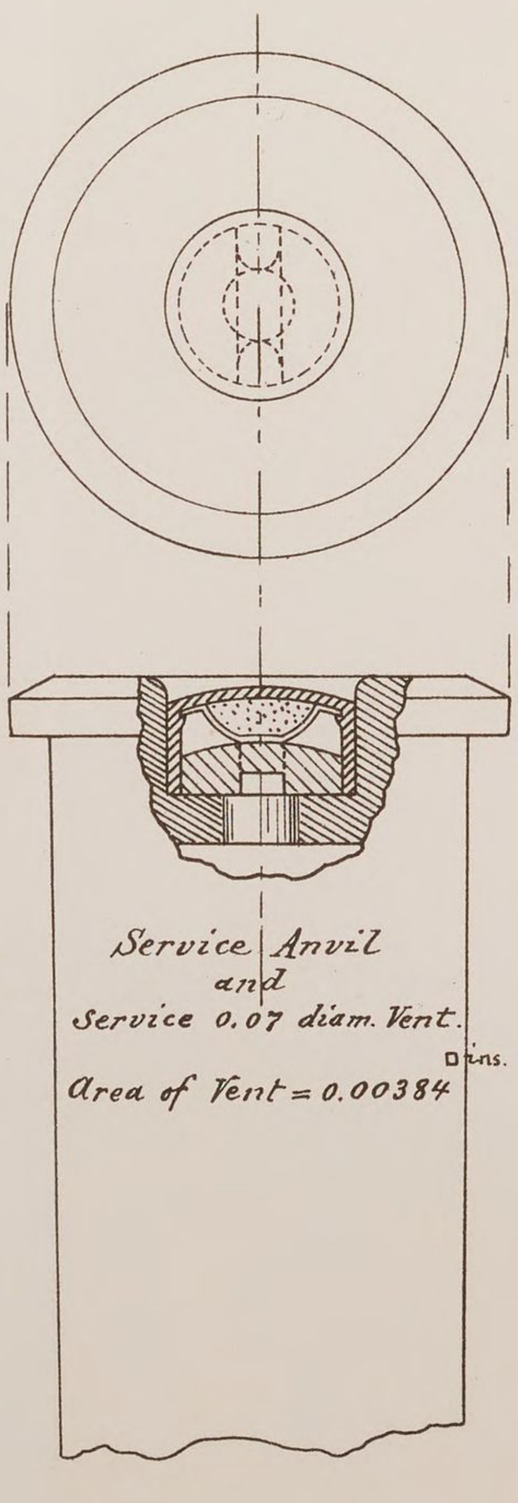
Mauser Anvil
used with Service
Primer

Area of Vents = 0.00140 $\frac{\square ins}{}$



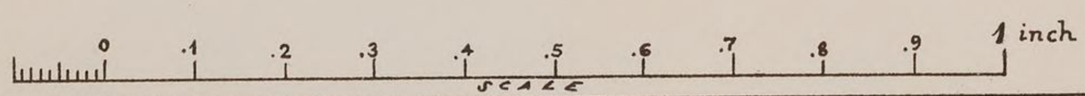
Modified Anvil
and 0.05 diam. Vent

Area of Vent = 0.00196 $\frac{\square ins}{}$



Service Anvil
and
Service 0.07 diam. Vent.

Area of Vent = 0.00384 $\frac{\square ins.}{}$



APPENDIX 16.

LABORATORY INVESTIGATIONS OF POWDERS AND EXPLOSIVES AT FRANKFORD ARSENAL, PENNSYLVANIA. REPORT BY CAPT. JOHN PITMAN, ORDNANCE DEPARTMENT, U. S. ARMY.

(2 plates.)

CHEMICAL LABORATORY,
Frankford Arsenal, Pa., August 1, 1893.

SIR: In accordance with your instructions of May 5, 1893, I have the honor to report the operations (during the year ending June 30, 1893) at the chemical laboratory, established for the investigation of smokeless powders, etc.

A one-story, iron frame, wooden building (Laidley laboratory), containing an office 22 by 22 feet, and a work-room 76 by 22 feet (height of ceiling 14 feet 10 inches), situated near the northeast corner of the arsenal, was selected for that purpose. It is well lighted, ventilated, and heated by means of coils along the walls, fed by low-pressure steam from a furnace located in the cellar.

There is also a good supply of water and gas; as the latter manufactured at the post proved too rich for chemical purposes, the supply is drawn from the city mains. A plan and photographs of the laboratory are herewith inclosed.

An estimate for the required material and work having been prepared, the fitting up and equipping commenced as soon as the money for that purpose was allotted.

As it is the intention, eventually, to measure the amount of gas developed by the explosion of the various powders and high explosives, as well as to determine the kind evolved under variations of the density of loading, a set of Prof. W. Hempel's gas apparatus and a Quinan gauge, etc., were included in the equipment.

The construction of the explosion chamber is still under consideration.

In order to prevent accidents in case of fire, a small magazine about 5 feet square was constructed, at a safe distance from the laboratory, for the purpose of storing samples.

The great facilities afforded at this post have forwarded the work of constructing and repairing apparatus.

The present programme is to examine, at the laboratory, samples of smokeless powders as regards composition, chemical and physical properties, which, taken in connection with the ballistic results (for small callibers) obtained at the proof-house, may serve as a guide in determining a powder best adapted for military purposes.

Such a powder should produce uniformly the requisite velocity with moderate pressure. Should not corrode the bore of the piece or the cartridge case, and must possess good keeping qualities. It should

not be affected by shocks and any changes in temperature or atmospheric moisture likely to occur. Should produce little or no smoke, and leave no hard, adherent residue in the bore. The granulation should be of such a form as to admit of uniform loading by machinery and without unusual risk in manufacture. Nitrocellulose, in some of its forms, will probably form the base of such a powder.

Whether the presence of nitroglycerine in reasonable quantity in a powder be objectionable is still an open question.

Means are being taken to test the effect of low temperatures on such powders, in order to ascertain if the exudation of the nitroglycerine has been prevented.

The Wetteren powder exposed in the open air at Fort Snelling, Minn., during the winter of 1892–'93, when returned to this post showed no effects of exudation, although this powder contains some 16 per cent of nitroglycerine.

The methods used during the past year in analyzing smokeless powders were those given by Capt. Hess, Austrian army, of which the following is a general outline:

The powder, cut into thin slices, is dried in a partial vacuum over sulphuric acid until the weight becomes constant. Loss: moisture or volatile matter. It is then treated with a mixture of alcohol and ether at a temperature of about 86° F. for some time and the solution filtered. From this solution the soluble pyroxyline or nitro-cotton is precipitated on addition of chloroform. The resin is separated by boiling with soda and precipitated by hydrochloric acid. The nitroglycerine is taken up with strong alcohol, and the sulphur by boiling with ammonium-sulphide, leaving the paraffine. The nitrates, etc., are extracted from the portion insoluble in alcohol-ether by means of water. The gun-cotton is removed by boiling with a solution of sodium sulphite. A dilute solution of hydrochloric acid removes the carbonates. The final residue is examined under the microscope, and ignited to determine ash.

The above methods were not entirely satisfactory, but were the best I could obtain at the time.

Samples of the following high explosives and powders have been received:

Explosives.—Walsrode gun-cotton, Germany; Emmensite, United States.

Powders for cannon.—Cordite, Armstrong rapid-fire gun; Troisdorf II, field guns, Germany, smokeless; Troisdorf III, field guns, Germany, smokeless; black cubical, 8-inch rifle, Germany, smokeless; B. N., 12-inch rifle, France, smokeless.

Powders for small arms.—B. N. F., France, smokeless; Hore, United States, smokeless; Leonard "J.," United States, smokeless; Leonard "N.," United States, smokeless; rifleite, for caliber .30, England, smokeless; S. V., for revolver, England, smokeless; S. R., for caliber .45, England, smokeless; Swiss smokeless, Switzerland, smokeless; Troisdorf I, Germany, smokeless; Wetteren, black, Belgium, smokeless.

So far the examination of smokeless powders at the Frankford Arsenal laboratory is not sufficiently far advanced, nor will my knowledge of the subject warrant my making definite recommendations as to the direct line of investigation to be pursued, for the purpose of obtaining a smokeless powder for service.

It is my purpose, however, to carefully examine the various types of smokeless powders obtainable, with regard to their chemical and physical properties, in order to obtain the requisite data.

The subject is quite intricate, as slight changes in the composition of the explosives or variation in the method of preparation of those of the same composition will produce powders having different ballistic qualities.

WETTEREN POWDER.

This powder was received from Cooppal & Cie, Belgium, through Messrs. Du Pont & Co., in April, 1891.

It consists of grains of a dead black color (said to be due to aniline black), mostly of a cubical shape apparently formed by cutting sheets of the material about 0.04 to 0.05 inch in thickness into squares about 0.05 by 0.05 inch; some grains are larger while others have the general shape of circular segments.

A sample of 3,000 grains, sifted on a set of sieves having circular holes ranging from 0.1 to 0.06 inch gave the following results, as to size of grains and velocity obtained from each size, using a charge of 36 grains with a 230-grain bullet in the 0.30-caliber experimental rifle:

+0.10 1.267 per cent, velocity below 500 feet.
+0.09 6.533 per cent, velocity 1,631 feet.
+0.08 25.200 per cent, velocity 1,692 feet.
+0.07 43.700 per cent, velocity 1,801 feet.
+0.06 20.567 per cent, velocity 1,879 feet.
—0.06 2.733 per cent, velocity 2,015 feet.

The average velocity of the unsifted powder, with like charge, was about 1,950 feet.

The material could be indented by the finger nail, and had a specific gravity of 1.53.

Temperature of ignition, about 290° F.

Exposure for twenty-four hours to a temperature of 120° F. caused the powder to lose 1.5 per cent in weight.

Thirty-six grains of this powder (equivalent to 36.54 grains of the ordinary Wetteren powder) with 220-grain bullet gave in the .30-caliber experimental rifle a velocity of 2,014 feet.

In a closed box over water, for the same period, the powder gained 2.01 per cent, producing a velocity of 1,720 feet. The grains showed a tendency to adhere and the powder felt damp.

A portion of this powder, after air-drying for one and three-fourths hours, showed a loss of 1.62 per cent of the original weight, felt quite dry, and the velocity increased to 1,893 feet.

The ordinary Wetteren powder, under similar conditions of loading, gave at the same time 1,994 feet velocity.

Exposed for eight days over water, the gain was 2.50 per cent, and the velocities varied from 1,481 feet to 1,519 feet. Nearly every charge hung fire.

Boiled for seven hours and then thoroughly dried over sulphuric acid, a velocity of 1,960 feet was obtained. The loss of weight was not determined.

The water extracted some nitroglycerine, but the form of the grain was apparently not affected.

A residue of 4.2 per cent remained after flashing two grammes on a weighed glass plate, although when used in the cartridge case very little residue was apparent.

The powder seems to possess good keeping qualities, and I think much of the variation in velocity is due to irregular granulation.

I would therefore recommend that in testing all powders the granulation be made as uniform as possible by careful sifting.

B. N. POWDER.

This powder was received from Sandy Hook proving ground in September, 1892. It is in the form of plates, about 5½ by 2 by ⅛ inch, of a dull yellow color, and the weight of each piece is about 460 grains. On outer surface are longitudinal blisters, with which holes in the interior generally correspond. These would indicate that a solvent had been employed in the manufacture of the powder. It is difficult to cut this powder with a knife, is brittle, and of a horny texture. It becomes highly electrofied when sliced, and exposure to the sunlight for a few hours causes the surface to assume a brownish tinge. Specific gravity, 1.46. This powder is not easily ignited. In fact, holes ¼ inch in diameter could be burned in the powder by means of a glass without igniting the remainder. The temperature of ignition was obtained by cutting the powder into small pieces, about ⅛ inch square, and placing them in a heated copper tube. At 339° F. the pieces swelled and ignited in about 45 seconds; at 451° F., in 5 seconds.

When flashed on a weighed glass plate, 3.9 per cent was not consumed. This last was ignited in a crucible and 0.77 per cent of the original powder remained as ash.

A piece about 2 inches by $\frac{2}{16}$ inch, weighing 51.14 grains, exposed for 24 hours to 120° F., lost 0.7 per cent.

A piece about 2 inches by $\frac{2}{16}$ inch, weighing 51.76 grains, exposed 24 hours over water, gained 0.59 per cent.

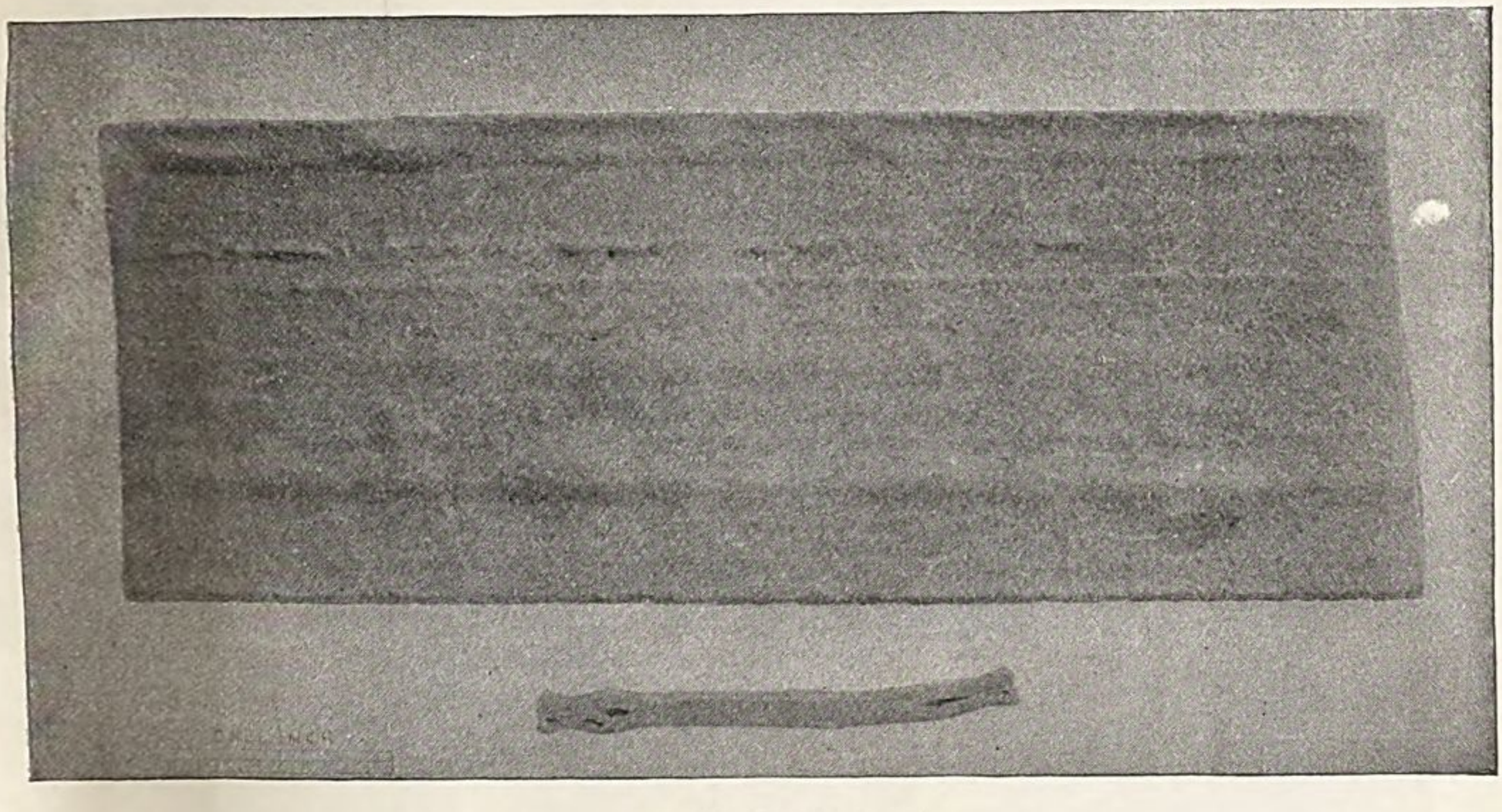
Very respectfully,

J. PITMAN,
Captain of Ordnance, in Charge of Chemical Laboratory.

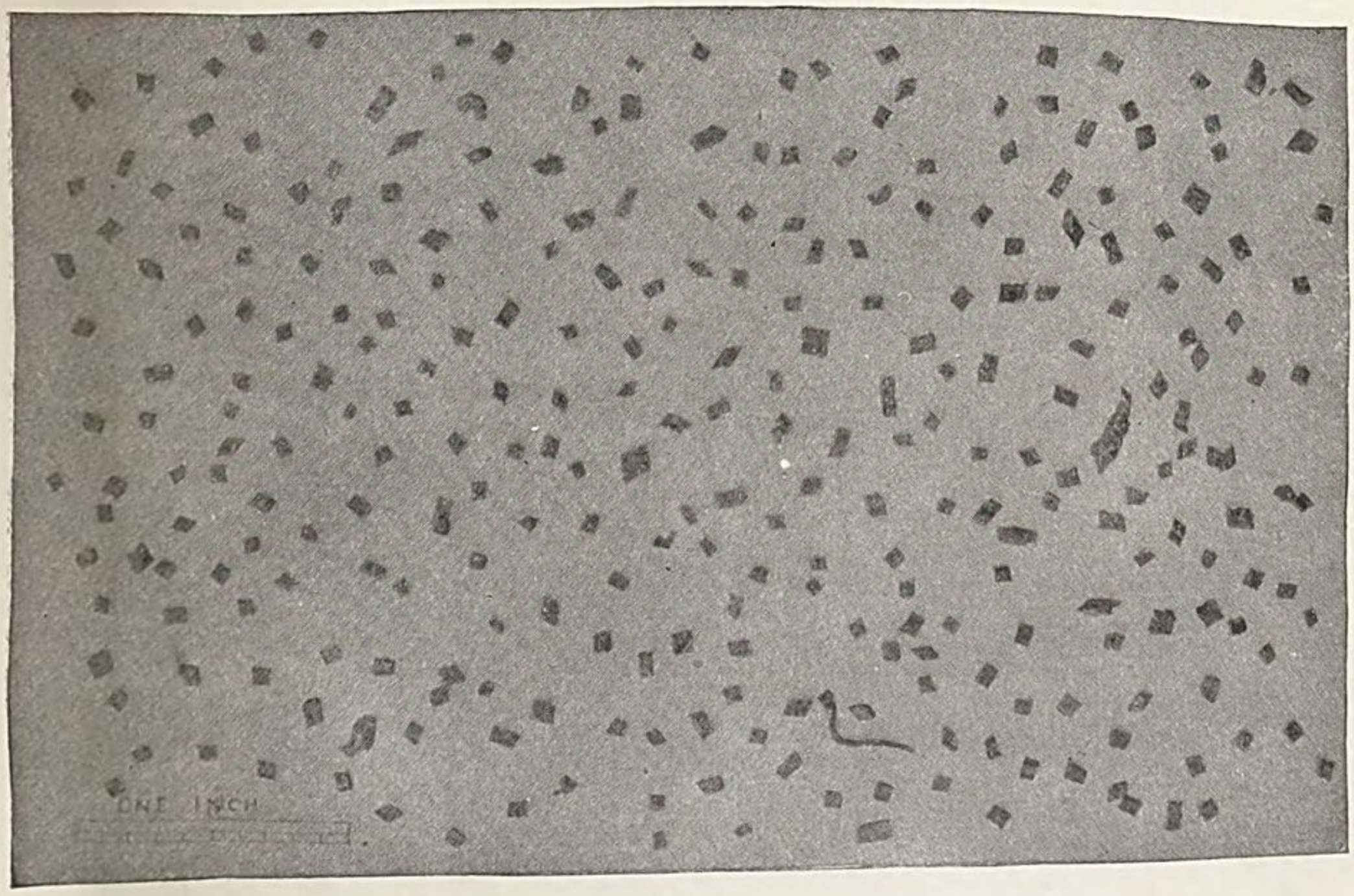
The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(Through commanding officer Frankford Arsenal.)

(4237–'93.)



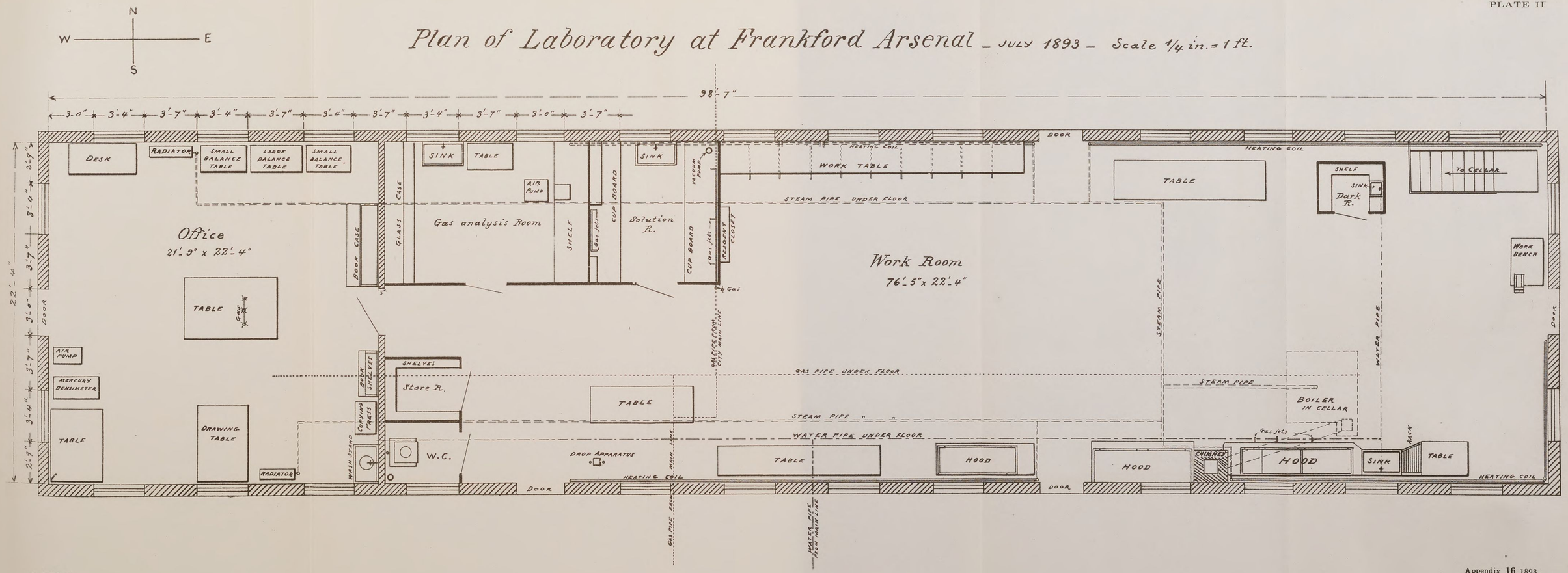
B. N. POWDER.



Appendix 16, 1893.

WETTEREN POWDER.

Plan of Laboratory at Frankford Arsenal – JULY 1893 – Scale 1/4 in. = 1 ft.



N
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APPENDIX 17.

MANUFACTURE OF CANNON FRICTION-PRIMERS AT THE FRANKFORD ARSENAL, PENNSYLVANIA. REPORT BY CAPT. FRANK BAKER, ORDNANCE DEPARTMENT, U. S. ARMY.

(1 plate.)

DESCRIPTION.

The cannon friction primer is a small metallic tube filled with gunpowder, which is ignited by drawing a flattened wire with serrated edges briskly through friction composition, contained in a smaller tube, inserted in the first near the top, and soldered at right angles to it. A lanyard, with a hook attached, is used to ignite the primer.

The tubes and wire may be made of either brass or copper. Copper, alloyed with from 5 to 7 per cent of zinc, is used at present.

COMPONENTS.

The components of the primer are one long tube, *a*, called the body; one short tube, *b*, called the branch; one wire igniter, *c;* friction composition, *d;* small arms powder, *e;* wax, *f*, and shellac varnish.

BODY.

The body is made from a circular disk of sheet copper, by means of a series of punches and dies, gradually diminishing in size to the last, which is of the required size of tube. Number of draws required, five.

To restore the ductility of the metal partially destroyed in drawing, it is annealed before the first and third draws. This is done in iron cylinders revolving in a special furnace. The metal is heated to a dark red color, plunged in a bath of thirty parts of water and one part of sulphuric acid to remove the scale, and then thoroughly washed in clean water to remove all trace of acid.

Thickness of copper disk: maximum, 0.036 inch; minimum, 0.035 inch.

The tube is cut to the prescribed length, measured from the closed end, by means of a circular saw; the holes for the branch and wire igniter are drilled and the burrs removed.

Length of body: maximum, 2.5 inches; minimum, 2.49 inches. Exterior diameter: maximum, 0.193 inch; minimum, 0.187 inch. Interior diameter: at mouth, 0.155 inch; at base, 0.145 inch. Diameter of hole for branch, 0.159 inch.

BRANCH.

The branch is made in similar manner to the body, and from metal having a thickness of 0.026 inch maximum, 0.025 inch minimum. Diameter of disk, 0.625 inch.

Number of draws, 5. Annealed before first, second, third, and fourth draws.

It is cut to the proper length by circular saws, placed at the required distance apart, and the burrs removed by rolling in a barrel.

Length of branch, 0.44 inch. Exterior diameter: maximum, 0.159 inch; minimum, 0.157 inch. Interior diameter, 0.142 inch.

One end of the branch is dipped in a solution of zinc chloride, inserted in the hole drilled in the body, held in the flame of a gas jet until solder melts and soldered with soft solder to the body, washed and dried, and the body reamed at its junction with the branch.

WIRE IGNITER.

The wire igniter is made of copper wire. Diameter: maximum, 0.055 inch; minimum, 0.054 inch, annealed before its last draw, cut to the proper length and pressed flat on one end by a machine for the purpose. The flat end is serrated by a punch and die with dentated edges and the tip annealed in a gas jet.

Length, 3.1 inches; length of flattened end, 0.5 inch.

FRICTION COMPOSITION.

The friction composition is made of 52.74 parts of antimony trisulphide, 35.16 parts chlorate of potash, 3.3 parts gum arabic, 4.4 parts flowers of sulphur, and 4.4 parts ground glass, prepared in the following manner:

Put the gum arabic in 8 ounces of water, allowing it to stand until all is dissolved. About three days' time is required. Strain through toweling to remove sediment. Pulverize thoroughly the chlorate of potash and pour into the gum solution, stirring well for a few minutes until dissolved. Add the antimony trisulphide, stirring the mixture until it is thoroughly incorporated. Care must be taken during this operation to keep the mixture moist, but if 8 ounces of water is used at first no more will be needed.

The sulphur and ground glass are then well mixed together with a spatula and thoroughly incorporated with the mixture, which must be in a moist condition when these are added, else there is danger of an explosion. The whole mass is then stirred for one hour.

Three hours' time is required for making the completed mixture.

Enough composition is mixed at one time to suffice for 9,000 primers, as this is a convenient quantity for thorough manipulation. The composition is tested, before use, by making and firing 25 primers. Should any lack of proper action be developed careful investigation is made to ascertain the cause, which may be due to lack of thorough incorporation or presence of moisture. If the difficulty can not be ascertained a new lot of composition is made. To preserve the thoroughness of incorporation the composition is worked over for about half an hour daily with a spatula. It should be made one week in advance of use.

CHARGING AND VARNISHING.

The branch is charged by pressing the open end in the friction composition, spread on a flat piece of zinc and brought to the consistency of soft putty, the body being closed with a metallic plug, *g*, having a conical point. This point reaches nearly to the line of the wire igniter and provides a ventage to the powder charge.

A conical hole is made in the composition while yet moist with a conical drift, *h*, inserted in the branch and the surplus composition removed; the wire igniter is passed through the branch and the hole in the body, the round end first, leaving the annealed tip projecting out of the open end, which is then closed by pressing the top and bottom firmly together with pinchers and bending the tip against the bottom. The end of the wire igniter is doubled on itself and twisted three and one-fourth times, leaving a loop 0.2 inch in diameter.

The primers are now placed in a dry room having a temperature of 140° during the day and 100° during the night for twenty-one days, except when removed for wiping off any surplus composition which may remain after priming, and again to coat the head of the primer, including the branch and joint, with shellac varnish, colored with lampblack. After the varnish hardens they are returned to the dry room and retained until the expiration of the prescribed time.

After drying 1 per cent of each day's manufacture is charged and fired for proof before proceeding further. There should be no failures nor delay in ignition.

The body is filled with dried small-arms powder (10 grains), and closed with beeswax mixed with tar.

The end is then touched with varnish and the primer thoroughly dried.

Great care is taken during priming and charging to exclude moisture from the primer. The operations should be conducted in a warm, dry room, and the powder should be kept carefully covered.

The material for closing the end of body is made of two parts of beeswax and one part of North Carolina tar, boiled two and one-half hours over a slow fire, constantly stirred to prevent burning, and then allowed to cool.

PACKING.

Fifty primers are packed in a cylindrical tin box (japanned) of the following dimensions: Depth, interior, 3 inches; exterior, 3.06 inches; diameter, interior, 2.65 inches; exterior, 2.7 inches. The cover fits tightly, and the joint is covered with a paper label giving the contents, place, and date of manufacture. One hundred tin boxes are packed in a wooden box having the following dimensions: Interior, 14.375 by 14.375 by 12.375 inches; exterior, 18 by 16 by 12 inches (over all).

The tin boxes are made from IX tin, bright. Each box requires three pieces, viz: Two circular for top and bottom (one piece 3.5 inches diameter; one piece 3.25 inches diameter) and one rectangular for body 3 by 9 inches.

FRICTION PRIMERS FOR LIFE-SAVING SERVICE.

A friction primer is also made for the use of the U. S. Life-Saving Service. This primer has a body 1.75 inches long, made by cutting to length the body tube of the service primer. The charge of small-arms powder used is 7 grains. In every other respect it is identical with the service primer and, with the above modifications, the description of the manufacture of the latter is applicable to this primer.

Fifty primers are packed in a cylindrical tin box of the following dimensions: Diameter, 2.75 inches; depth, 2.25 inches.

Five thousand primers are packed in a wooden box of the following dimensions: Interior, 14.5 by 11.75 by 11.5 inches; exterior, 18 by 13.5 by 13.25 inches (over all).

INSPECTION, ETC., OF MATERIALS.

When received the metal for body and branch is weighed, gauged for thickness and width, and inspected for flaws and imperfections. The wire is weighed, gauged, and tested to see if when looped and twisted three times it will stand the required pull of 90 pounds without breaking or untwisting. The materials for the friction composition are weighed and inspected for impurities. The antimony trisulphide and chlorate of potash are tested by use in making and firing a number of primers. Glass is sieved to see if it is of the requisite degree of fineness.

Materials required for 100,000 cannon friction primers.

Copper alloy: (5 to 7 per cent zinc) for body, in strips 22.5 inches long, 4 inch wide, 0.036 inch maximum 0.35 inch minimum thick, end angle 90°	pounds..	1,220
(5 to 7 per cent zinc) for branch in strips 26 inches long, 2.6 inches wide, 0.026 inch maximum 0.025 inch minimum thick, end angle 90°	pounds..	125
Wire, copper alloy, annealed before the last draw, diameter 0.055 inch maximum 0.054 inch minimum	pounds..	225
Wire, soldering	do....	12.5
Antimony trisulphide (needles of antimony)	do....	33.33
Chlorate of potash, powdered	do....	22.22
Flowers of sulphur	do....	2.75
Ground glass	do....	2.75
Gum arabic, lump	do....	2.08
Beeswax	do....	2
Tar	do....	1
Varnish (7.5 pounds gum shellac, 10 quarts alcohol, 2½ ounces lampblack)	quarts..	10
Soldering acid (muriatic)	do....	2.5
Small-arms powder	pounds..	150
Tin plate, best IX bright, charcoal. 20 by 28 inches, 0.016 inch maximum 0.014 inch minimum thick, suitable for seamless drawn boxes	sheets..	200
Box boards, 15 inches wide, 1 inch thick	feet..	240
Screws, 2-inch, No. 13	gross..	2
Nails, cut, 7 dwt	pounds..	9
Nails, clinch, 7 dwt., 2¼-inch	do....	1.5

Modifications in the foregoing bill of materials to be made for 100,000 friction primers for Life-Saving Service.

Small-arms powder	pounds..	105
Tin plate, quality and dimensions as above	sheets..	180

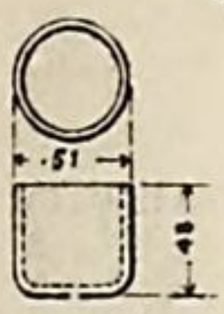
Respectfully submitted.

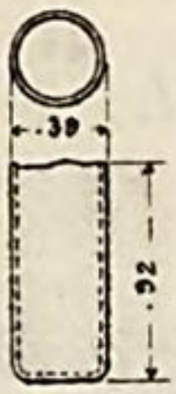
FRANK BAKER,
Captain, Ordnance Department.

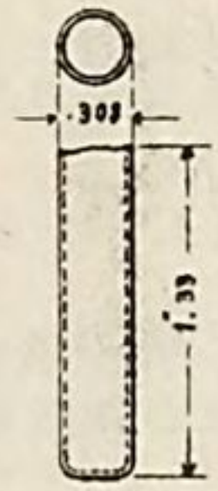
(780–'90.)

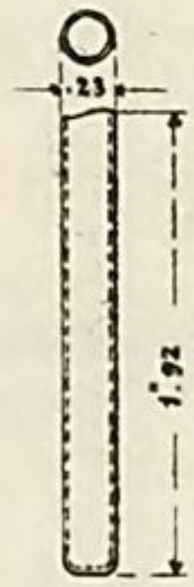
Cannon Friction Primer

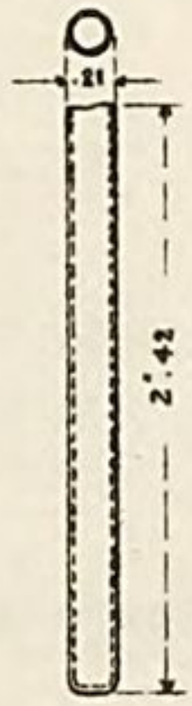
CUP AND SUCCESSIVE DRAWS FOR BODY

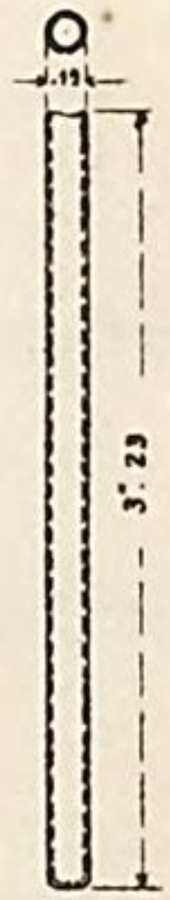






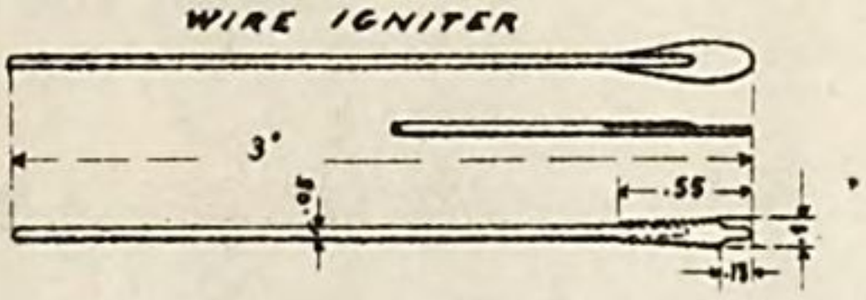




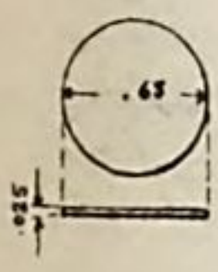


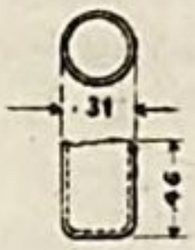
DISK FOR BODY

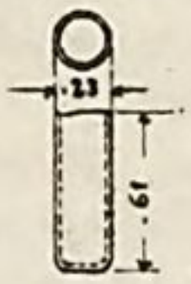
WIRE IGNITER

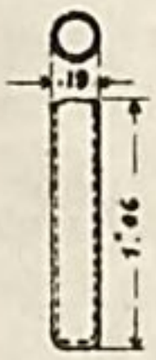


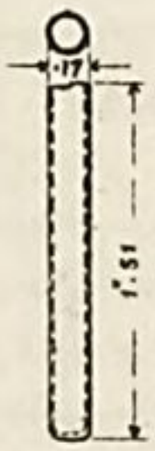
DISK, CUP AND SUCCESSIVE DRAWS FOR BRANCH

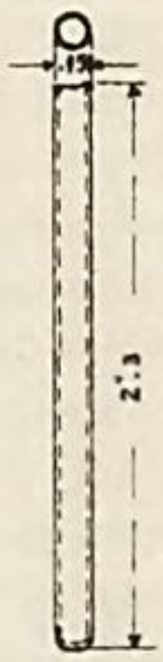




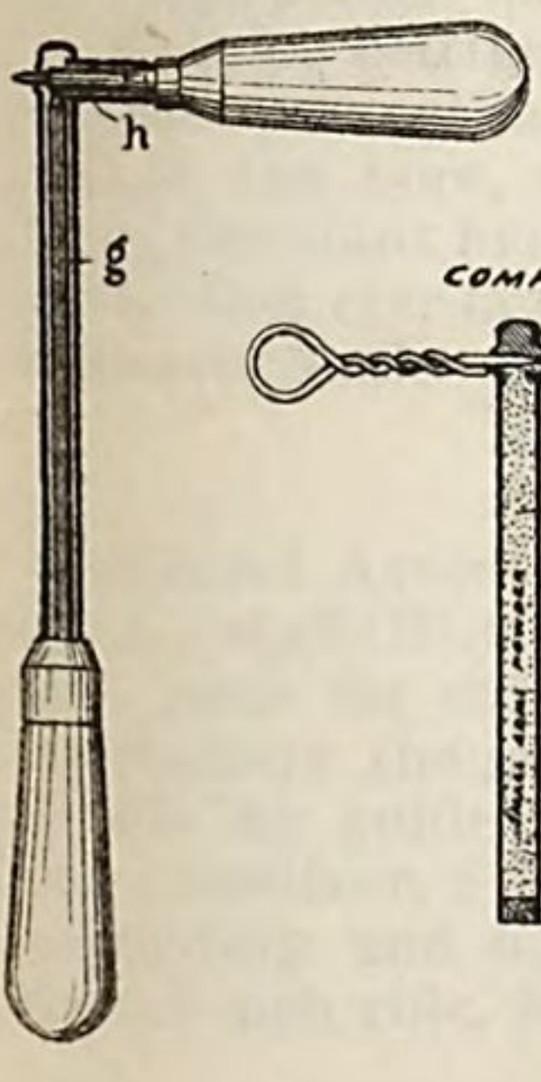




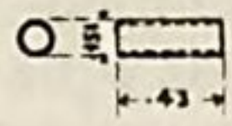




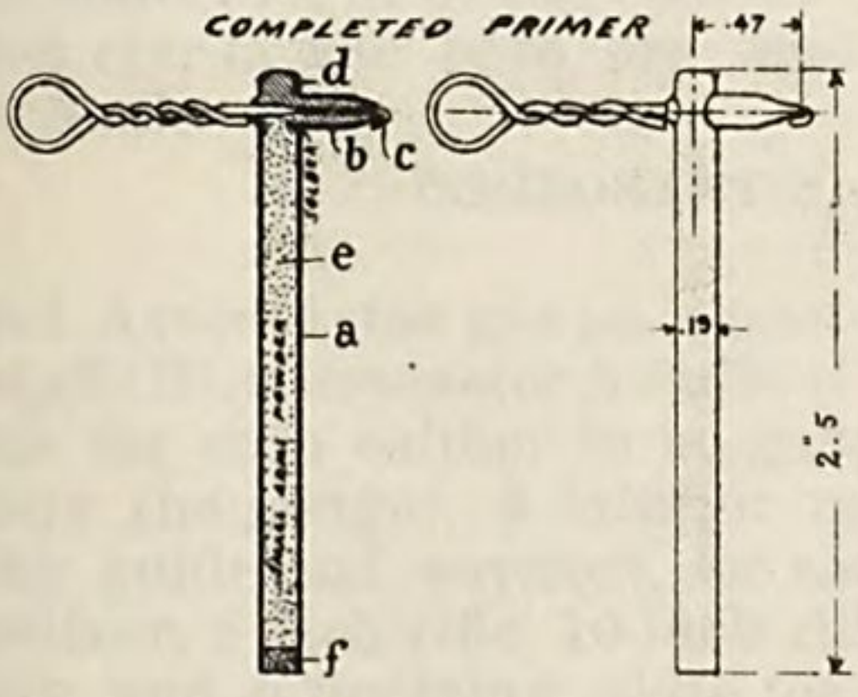
CHARGING BRANCH

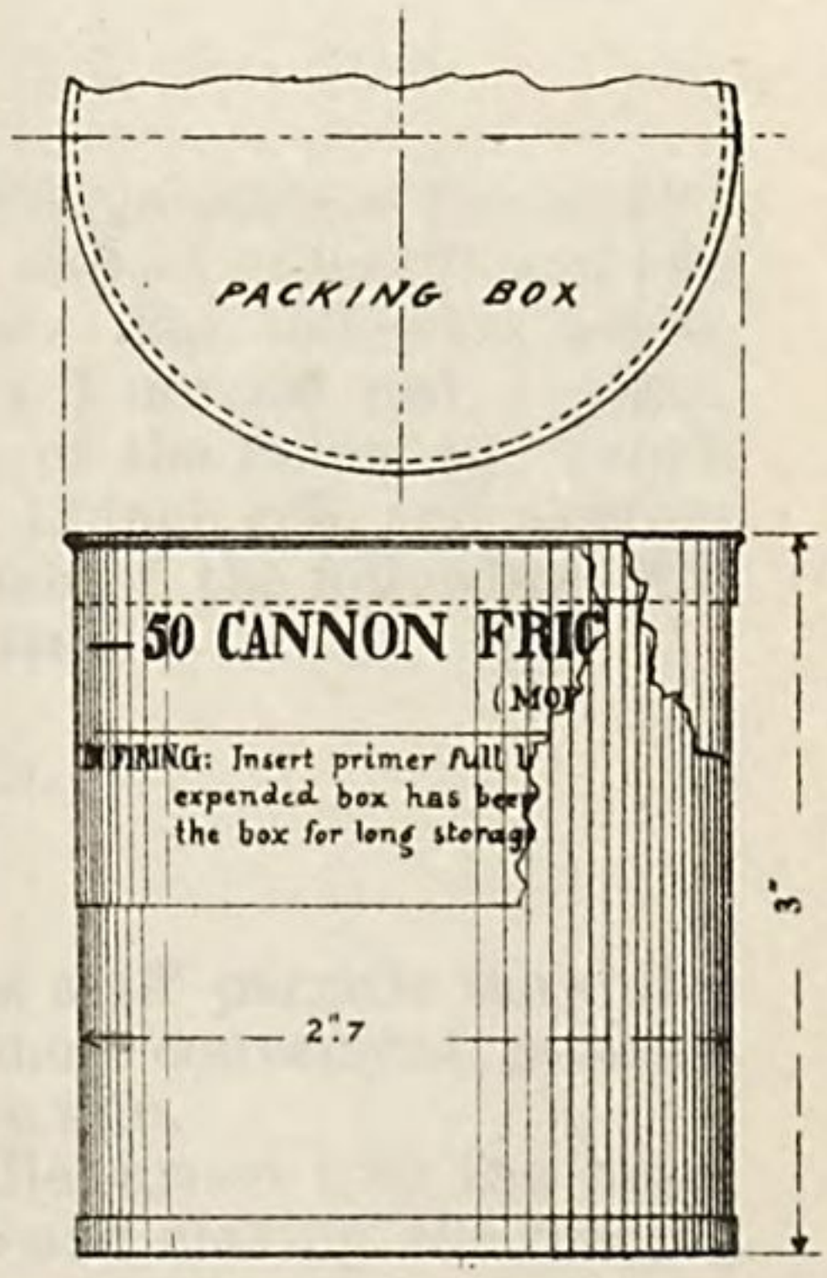


COMPLETED BRANCH



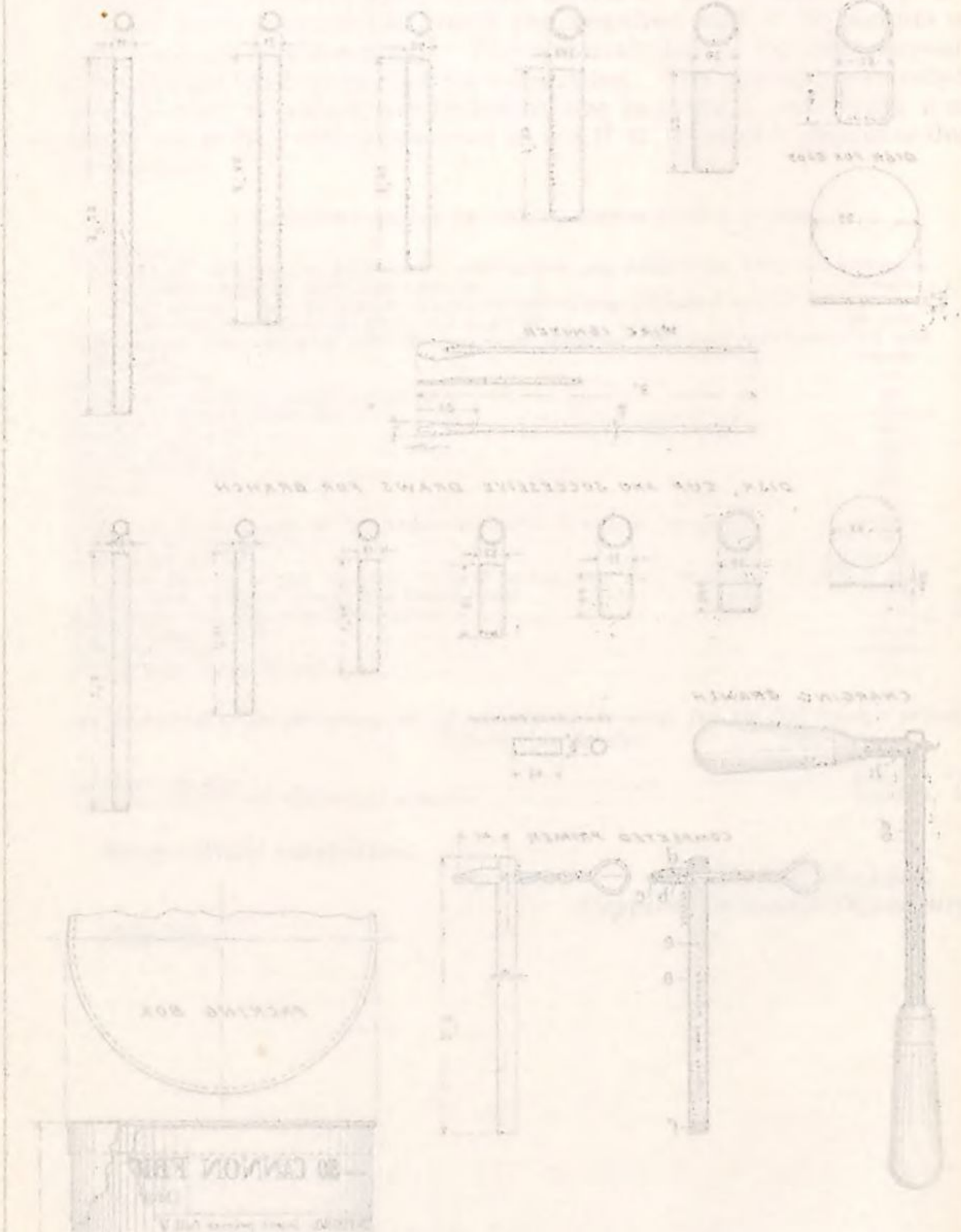
COMPLETED PRIMER





SCALE OF INCHES

PLATE I.



APPENDIX 18.

THE FRANKFORD ARSENAL STAR GAUGE, MODEL 1893, BY CAPT. FRANK BAKER, ORDNANCE DEPARTMENT, U. S. ARMY.

(5 plates.)

The star gauge is an instrument for measuring the diameter of the bore of a cannon at any point.

USE.

(Pl. I.)

In general terms the use of the gauge may be described as follows:

When the star gauge is assembled, points for gauging the required diameter are screwed into the sockets a_1, a_2, a_3, a_4, shown on the outer circumference of the head in Figs. 3 and 4. These sockets are held in place against the surface of the steel cone by springs *b*, Fig. 4. Forward movement of the cone by means of the handle and steel rod *c* presses the sockets against the springs and moves the points out in directions normal to the cylindrical portion of the head until brought in contact with the bore. The points having been first set to the required diameter (say 12 inches) by setting them against the interior surface of a 12-inch ring, and the scale on handle adjusted to read zero for this diameter variations in the bore, either plus or minus, are read from the scale. The ratio of the slant height of the cone to its altitude is such that the varations in diameter of the bore are read to thousandths of an inch on a convenient scale.

COMPONENTS.

The Frankford Arsenal star gauge, model 1893, consists of the revolving head (A), staff (B), micrometer handle (C), one set of points and one rifle guide plate for each caliber to be gauged. The following accessories accompany the gauge: 4 interior rests, 1 muzzle rest, 1 plate, serving both as guide and support, for each of the following: 7-inch mortar and howitzer, 8-inch rifle, 10-inch rifle, 12-inch rifle and mortar; and one guiding and supporting plate for each of the following: 3.2-inch rifle, 3.6-inch rifle, 5-inch rifle. (See Pl. III.)

THE REVOLVING HEAD.

(Pl. I, Figs. 3 and 4.)

Revolution of the head independently of the staff permits the scales on the staff and handle to be retained in the most convenient position for reading when star-gauging the rifling of the gun.

With the old style head the staff and handle turned with the head, continually changing the position of the scale and making the reading more or less inconvenient.

The head A is made of brass and has four brass holders *x x x x* for the steel sockets for points, fastened in position by means of a steel end plate *d* and screws *m m*. Two of these holders are stationary, and two are susceptible of limited motion about the axis of the star gauge, permitting an adjustment of the points to suit bores with an odd or even number of grooves, *i. e.*, with an odd number of grooves one fixed and two movable holders are used, while with an even number of grooves, as well as with smoothbores, two, three, or four holders may be used. The end plate is cut away, as shown at *j j*, to permit the necessary movement of the screws *k k*, which fasten the movable holders, for the required adjustments.

The points when in use are screwed into the steel sockets and the latter terminate on the interior in plane surfaces, making the same angle with the axis of the cone (D, Pl. I, Fig. 4) as its rectilinear elements. The sockets always rest on the surface of the cone and are held against it by springs. As the cone moves forward the sockets with the points are moved out at right angles with the axis of the gauge, and as the cone is drawn to the rear the sockets and points, actuated by the springs, are withdrawn.

The head revolves on a bronze tube with an exterior conical surface *e*, Fig. 4, secured to the neck *f* by the nut *g*. A large brass nut, *l*, unites the head and neck as shown in Pl. I, Figs. 3 and 4.

The neck is fastened permanently to the staff. The brass tube of staff is reënforced at its junction with the neck by an interior tube of steel, *h*, Fig. 4, Pl. I, abutting against a steel collar at the base of the cone. A hole in the steel tube permits the use of a pin wrench in screwing it to the cone. The rear end of this tube holds a steel ball, into which the steel rod of the star gauge screws. A nut screwed to the tube incloses the ball and holds it in place, being prevented from unscrewing by a jamb nut. The ball and socket motion thus provided for allows for any slight bending which may take place in the staff.

The head is made to revolve by means of a steel key, *i*, Figs. 3 and 4. By lifting the key it is withdrawn from its hole in the bronze tube *e*. Turning the key to the right, as indicated by the legend "For revolving," until it engages in the slot, permits the head to revolve. Lifting the pin from this position and turning to the left until it engages in the hole fixes the head with reference to the handle.

The first section of the staff is attached to the head and should only be removed for repairs.

THE CONE.

The cone is of steel and the radii of its base and altitude have a ratio of 1 to 6.5, hence for every unit of forward movement of the cone the points are thrust out $\frac{1}{6.5}$.

THE STAFF.

(Pl. I, Figs. 1, 2, 3, and 4.)

The staff consists of a brass tube made in eight sections for convenience of handling and packing. These sections are joined as shown in the plate. The tube is graduated in quarter inches for indicating the distance of the points from the muzzle of the gun. The end of the staff which enters the bore terminates in the head, while the other end is attached to the handle. A steel rod made in eight sections, corresponding to those of the tube is inclosed by the tube but has an independent

longitudinal motion. These sections are joined as shown in Fig. 1 of the plate. The end which enters the head is joined to the steel cone, while the other end is fastened to the handle.

The handle can be attached to any section of the staff, thus varying the length as required.

THE MICROMETER HANDLE.

(Pl. I, Fig. 2.)

This substitutes a screw motion for the sliding one used for small measurements with the old model star gauge.

The handle is of steel, joined to the staff by a brass tube *n* and clamp *p*, and to the end of the steel rod by the sleeve *r*, which is fastened to the casing so as to prevent rotation. The large screw engaging in the handle casing has five threads to the inch, right hand, while the small screw engaging in the sleeve attached to the steel rod has eight threads to the inch, left hand. For every revolution therefore of the micrometer handle the sleeve, and consequently the cone, moves forward $\frac{1}{8}+\frac{1}{5}$ inch=0.325 of an inch. The pitch of the cone is such that for every unit of its forward motion the points are thrust out $\frac{10}{65}$ inch, hence, for every complete revolution of the handle the points will move out 0.325 by $\frac{10}{65}$ inch=0.050 inch. The scale on the handle is divided into fifty equal parts.

The rings carrying the O of the gauge are clamped, after adjustment, by the locking ring *t*. Both rings have the surfaces knurled for convenience.

The handle of the micrometer scale is also knurled. The handle is nickeled, and the divisions of the scale are darkened for convenience in reading.

THE MUZZLE REST.

(Pl. II.)

This is made of steel, and consists of the staff-holder and three radial arms attached to it, as shown in the plate. The arms are graduated from 3 to 17 inches for use in bores between those limits.

The rest is held in the muzzle by slightly tapering pins attached to slides, which fit over the arms, being fastened thereto by clamp screws. Set screws give small motion to the slides in radial directions. The pins are made slightly increasing in diameter toward the outer end to guard against slipping in the bore.

A bronze clasp fits over the staff as an index for reading graduations on the tube.

THE INTERIOR REST.

(Pl. III.)

This consists of a short brass cylinder, Fig. 1*a*, called the clamp, and the rollers or rest plate supporting the staff in the bore. The clamp is made in three pieces, the half-circular part (carrying the socket-holder, Fig. 1*b*) and the two parts hinged to it, which are clamped to the star-gauge staff by a thumb screw.

The sockets *c* and *d* are the same as those in the star-gauge head. To them the rollers which support the staff in the bores of 7, 8, 10, and 12 inches and inclusive calibers are attached by means of plain steel rest points similar in construction to the measuring points, though

much simpler. The rollers are fastened to the rest points by means of sleeves and set screws.

For the 5-inch rifle the rollers are screwed directly into the sockets, while for the 3.2-inch and 3.6-inch rifles interior rest plates are provided, two for each caliber, one for shrinkage and one for finished diameters. Plate-holders are attached to the clamps for use with these rests.

MEASURING POINTS FOR SHRINKAGE, FINISHED AND CHAMBER DIAMETERS.

(Pl. IV.)

Points are supplied for measuring shrinkage diameters of 3.2, 3.6, 5, 7, 8, 10, and 12 inches, and with appropriate washers for measuring finished diameters for the same calibers. With washers provided, the points for 7-inch howitzer chamber may be used for 7-inch mortar chamber.

BORES.

For shrinkage diameters.	Point marked.		Washers.	For finished diameters.
Inches.	*Inches.*		*Inch.*	*Inches.*
12.0	11.75	and with	0.125	12.0
10.0	9.8	and with	0.1	10.0
8.0	7.875	and with	0.0625	8.0
7.0	6.875	and with	0.0625	7.0
5.0	4.875	and with	0.0625	5.0
3.6	3.5	and with	0.05	3.6
3.2	3.1	and with	0.05	3.2

CHAMBERS.

	Point marked.	
	Inches.	
For—		
12-inch steel rifle (model 1888)	14.2	
12-inch steel mortar	12.5	
10-inch rifle	11.8	
8-inch rifle	9.5	
7-inch howitzer	7.2	
7-inch mortar (model 1892)	7.2	with 0.02-inch washer.
5-inch rifle	5.7	
3.6-inch rifle	3.9	
3.2-inch rifle	3.5	with 0.05-inch washer.

RIFLE GUIDES.

Pl. V.

The rifle guides are made of steel, and set in steel rifle guide plates, as shown at *s s*, Fig. 1, for 7, 8, 10, and 12 inch calibers. The guides may be removed and others for different size grooves put in if desired.

A lever attachment permits the withdrawal of the guides within the circumference of the plate if used for head support. The plate is cut away, as shown, for lightness, and is attached for use to the end plate of head by means of nuts and screws. For 3.2, 3.6, and 5 inch bores the guides are cut on the peripheries of steel plates, which are left full circles for 3.2 and 3.6 inch, and cut away for the 5-inch rifle, as in the large plates. The method of attachment to the head is the same for all.

Respectfully,

FRANK BAKER,
Captain, Ordnance Dept., U. S. Army.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 30, 1893.

Star Gauge with revolving Head, Micrometer Handle and 400 inch Staff_ Model 1893 _ SCALE : FULL SIZE.

FIG. I

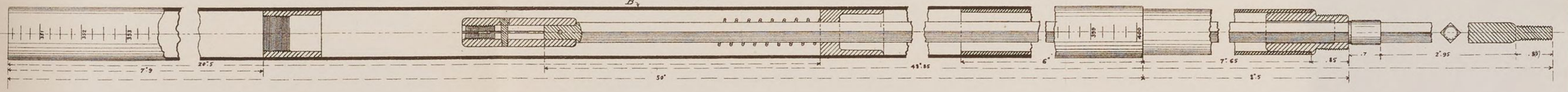


FIG. II

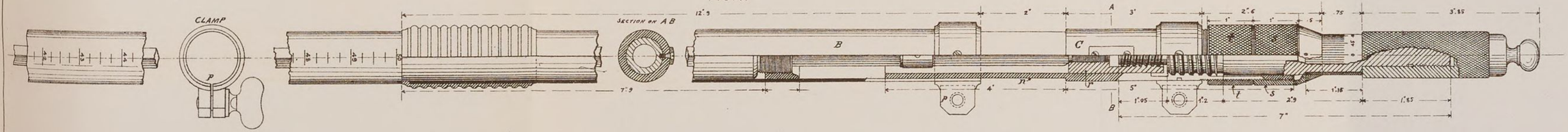


FIG. III

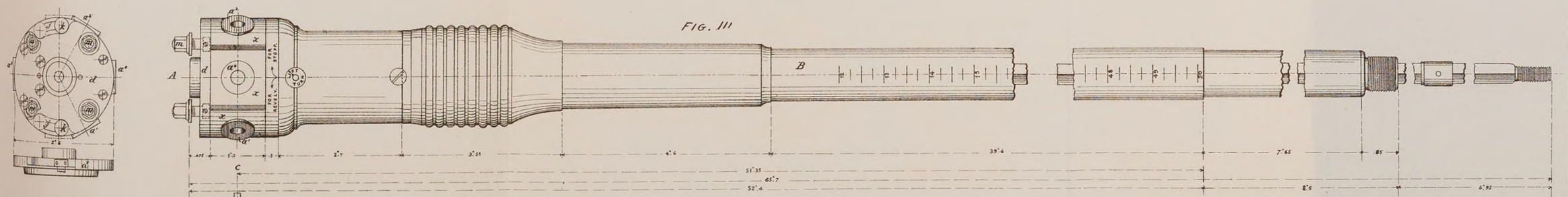
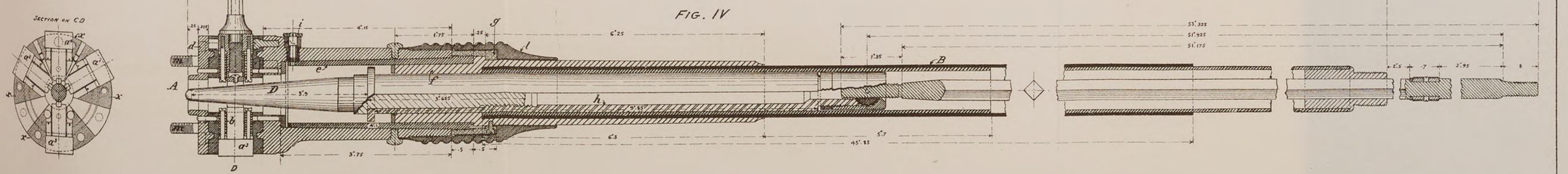
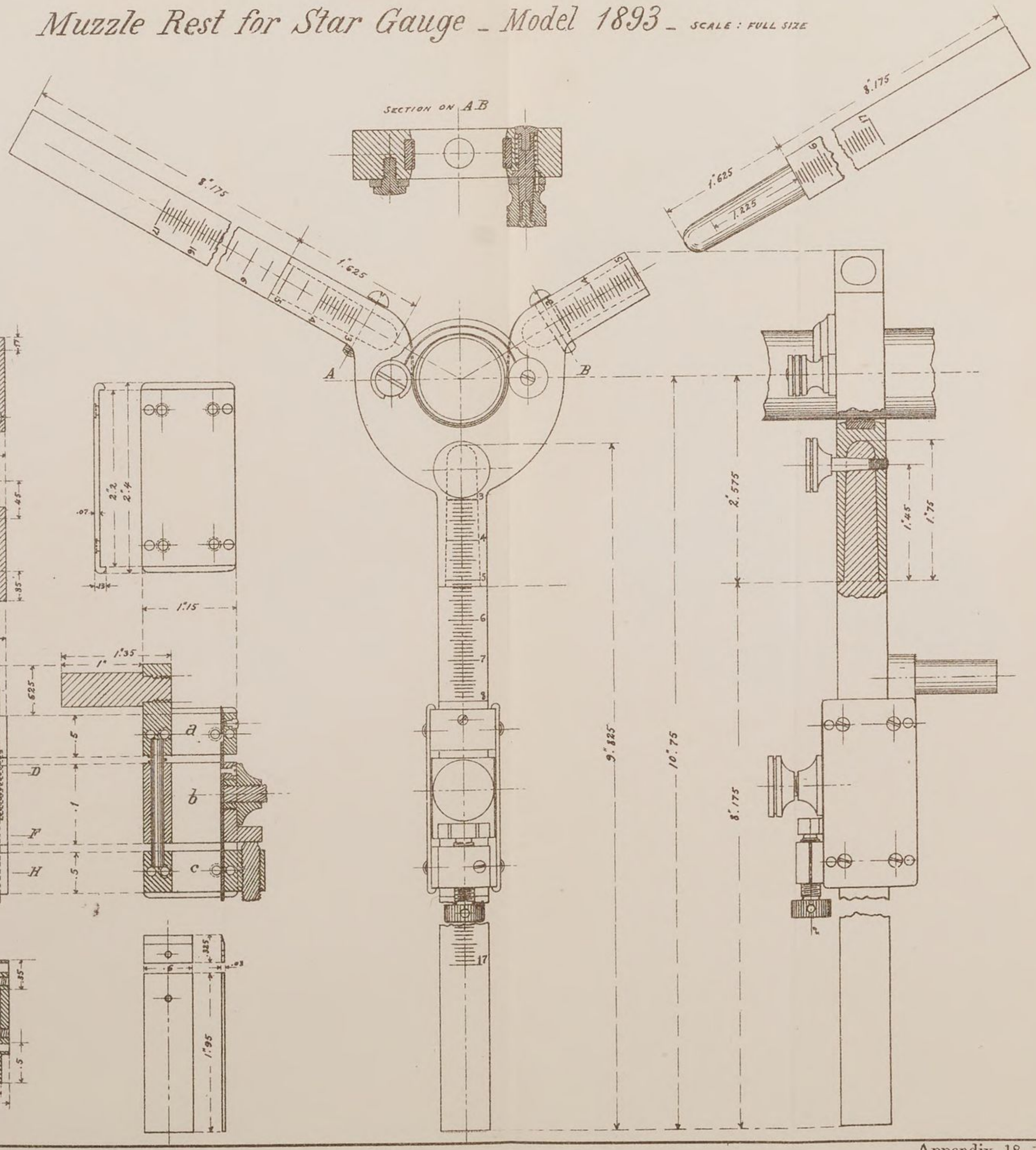


FIG. IV



Muzzle Rest for Star Gauge _ Model 1893 _ SCALE : FULL SIZE



Frankford Arsenal
August 1893

Interior Rest for Star Gauge – Model 1893 – SCALE : FULL SIZE

4 REST CLAMPS LIKE THIS FOR EACH STAR GAUGE

FIG. 1b

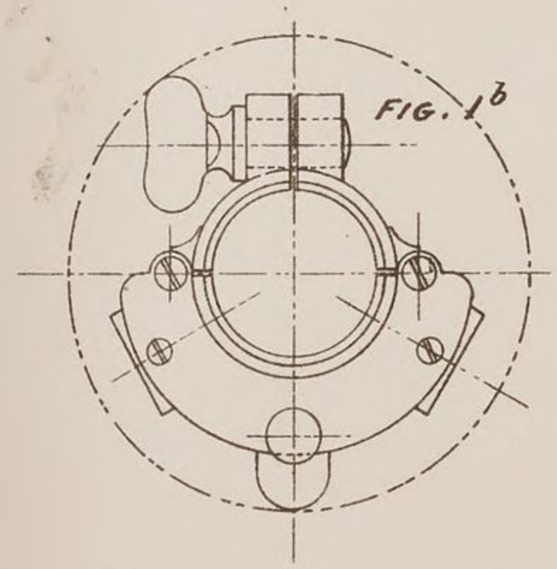


FIG. 1a

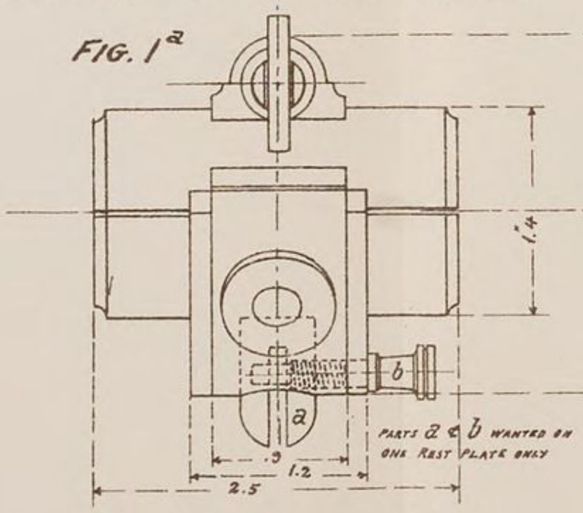
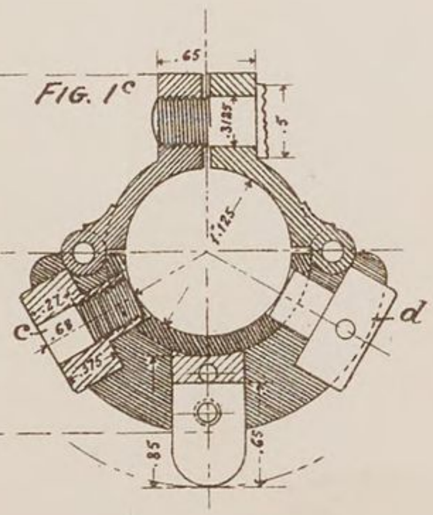
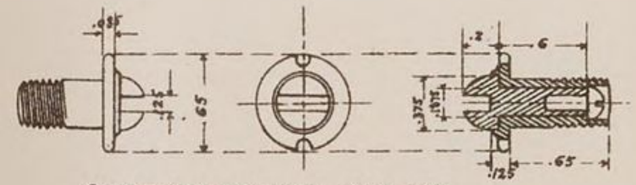


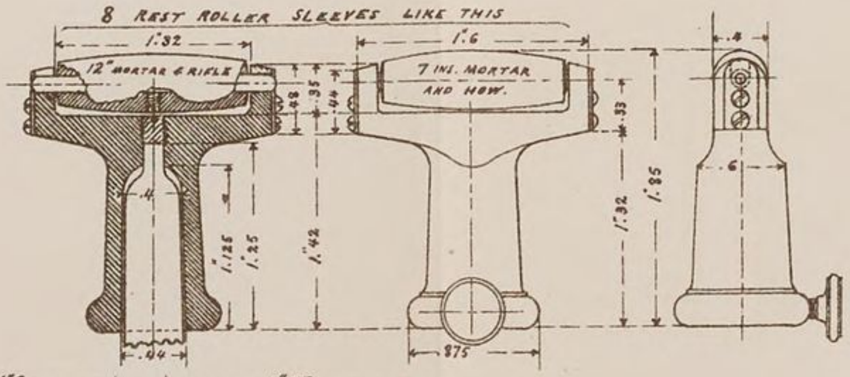
FIG. 1c



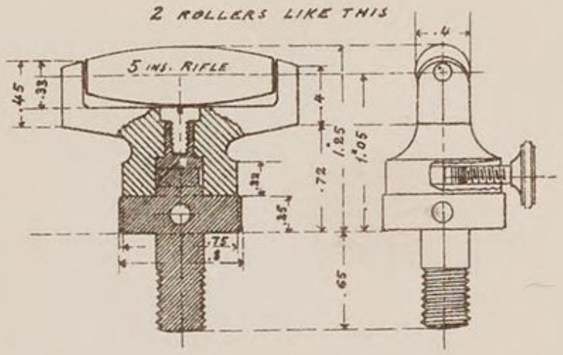
2 REST PLATE HOLDERS LIKE THIS

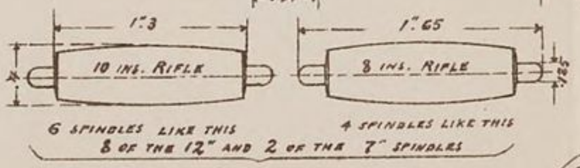


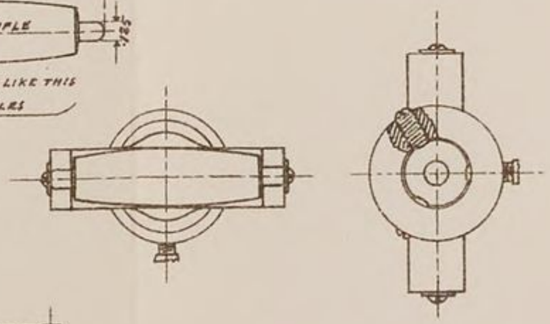
8 REST ROLLER SLEEVES LIKE THIS



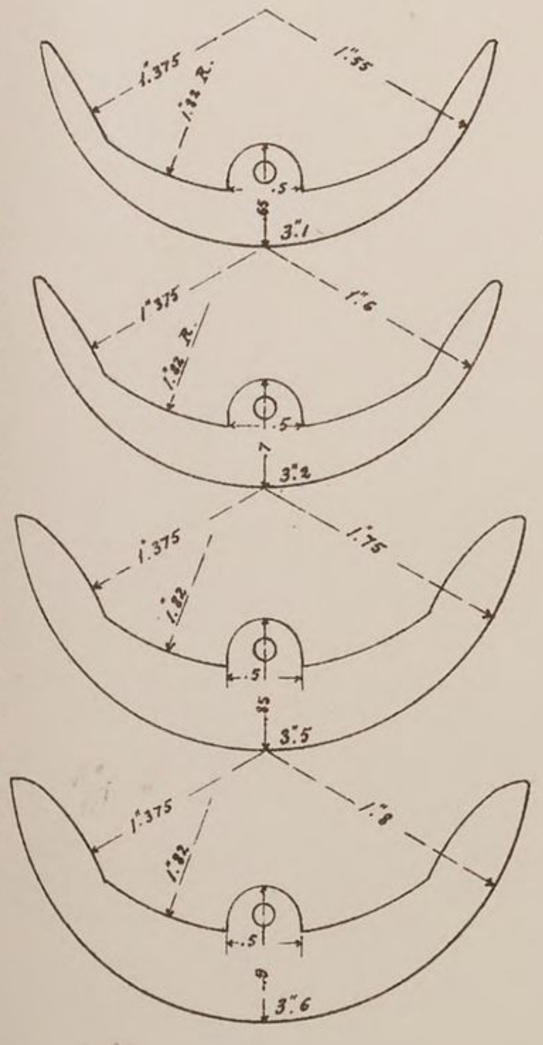
2 ROLLERS LIKE THIS

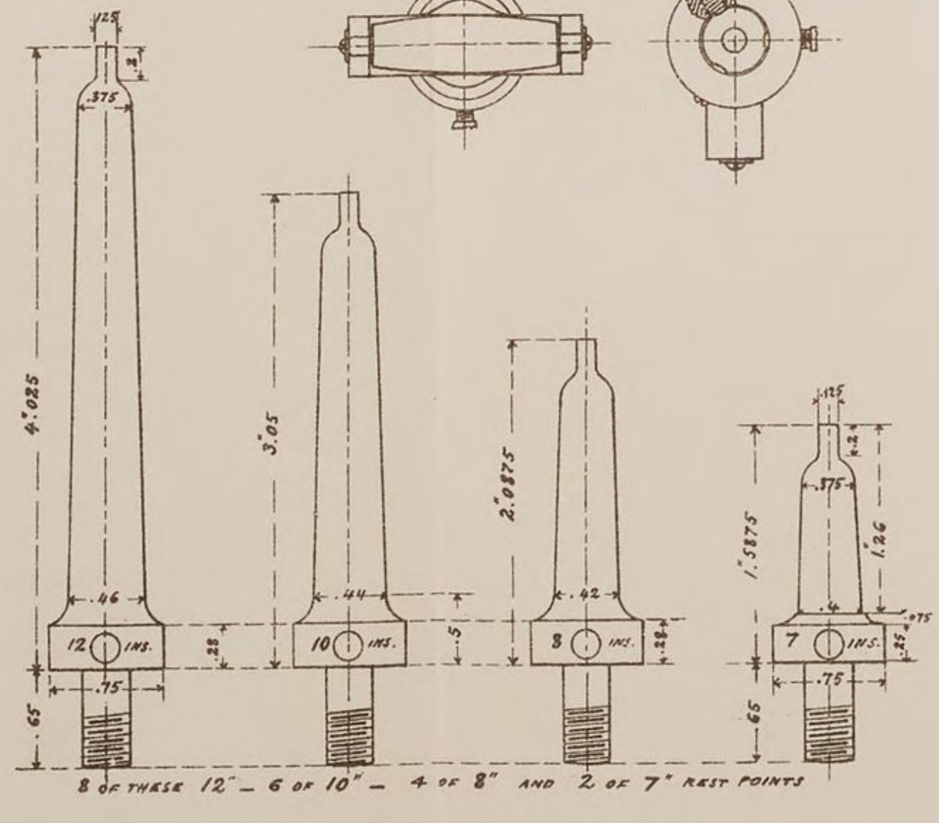






ONE OF EACH OF THESE REST PLATES, EVERYONE .125 THICK

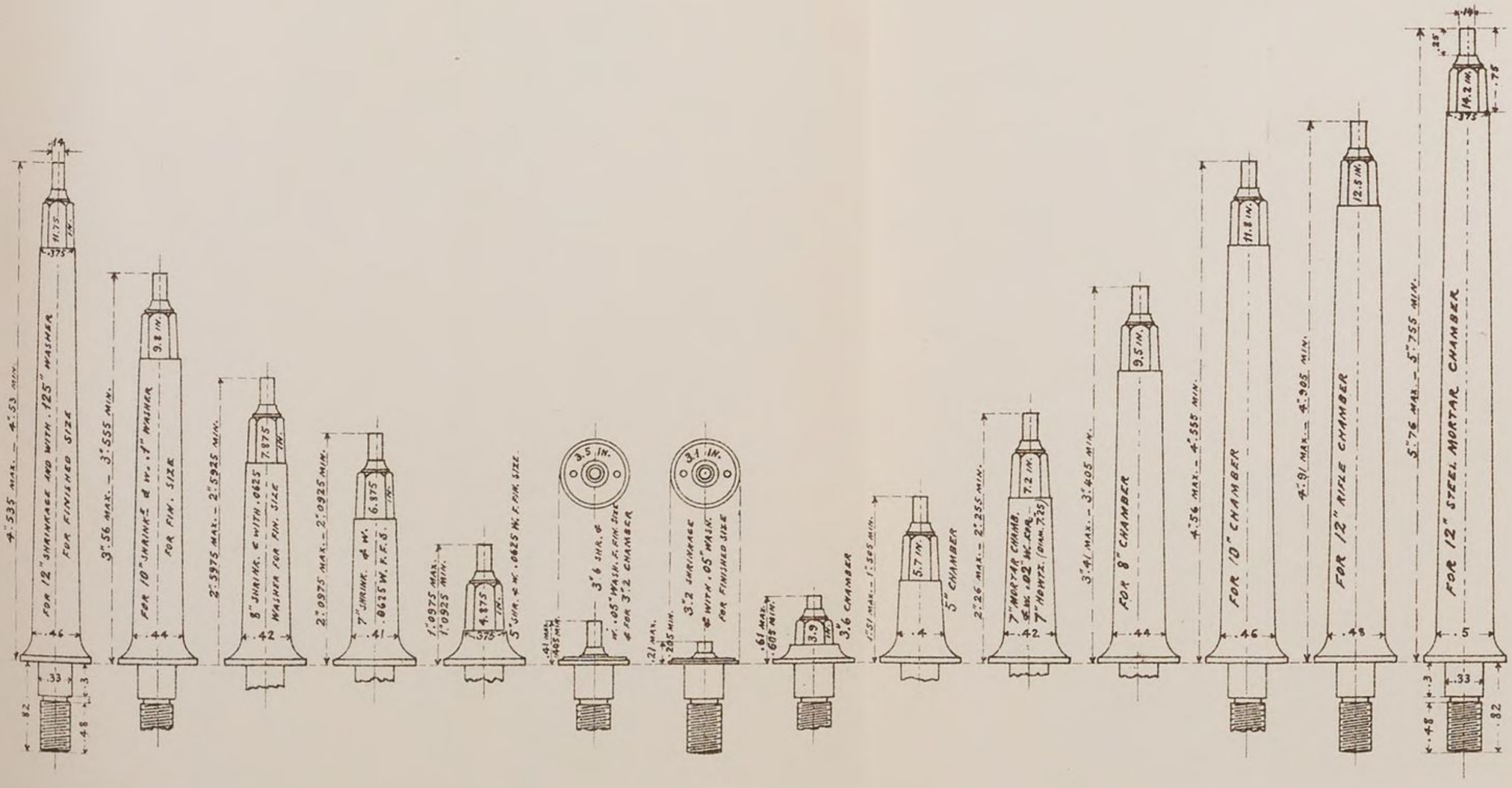




8 OF THESE 12" – 6 OF 10" – 4 OF 8" AND 2 OF 7" REST POINTS

4 SETS OF WASHERS FOR MEASURING POINTS AND 8 SETS FOR REST POINTS

Measuring Points for Shrinkage, Finished & Chamber Diameter for Star Gauge model 1893 – SCALE : FULL SIZE



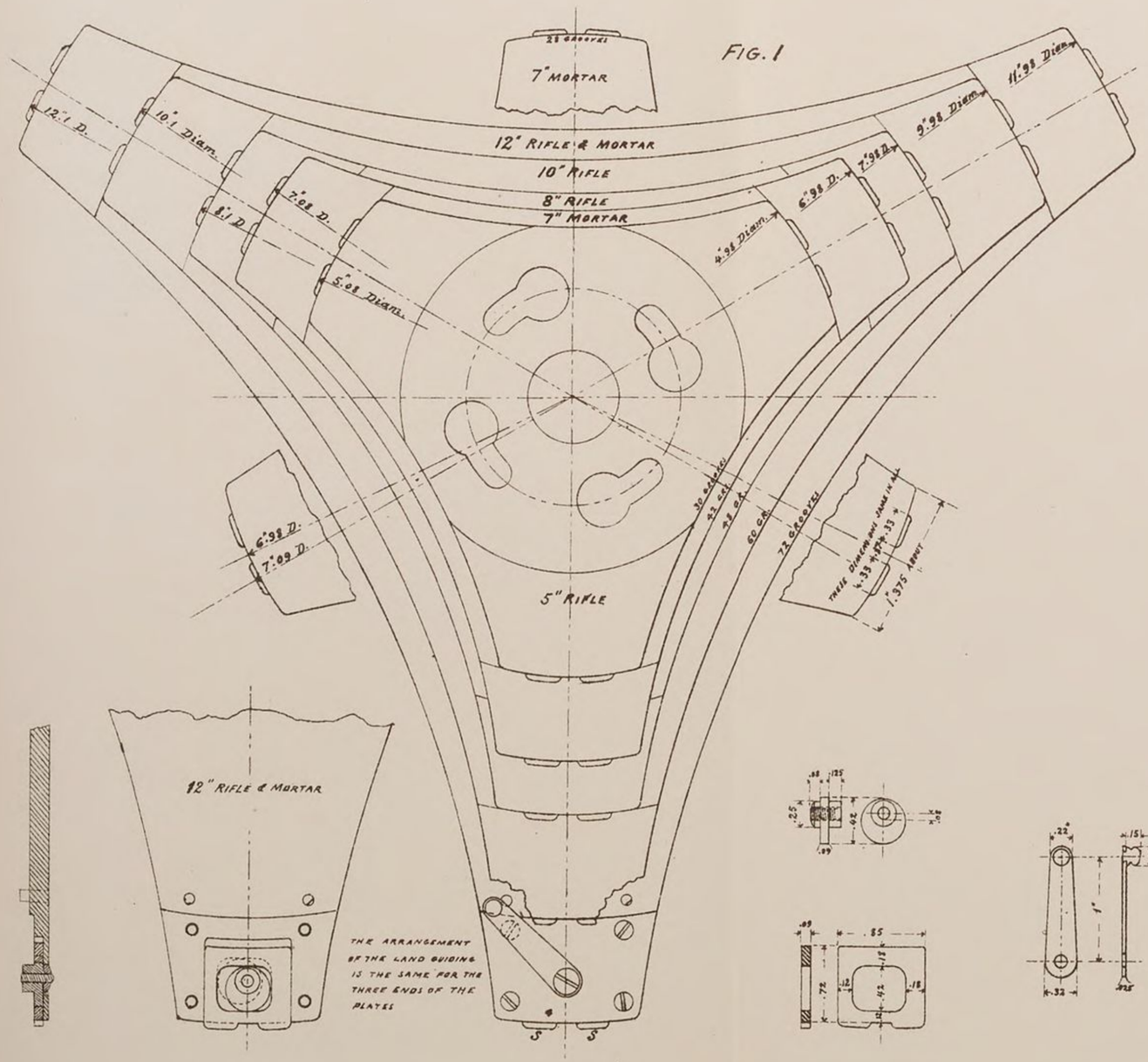
Frankford Arsenal

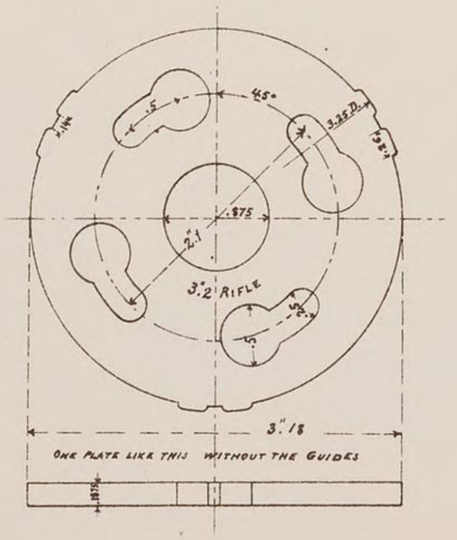
August 1893

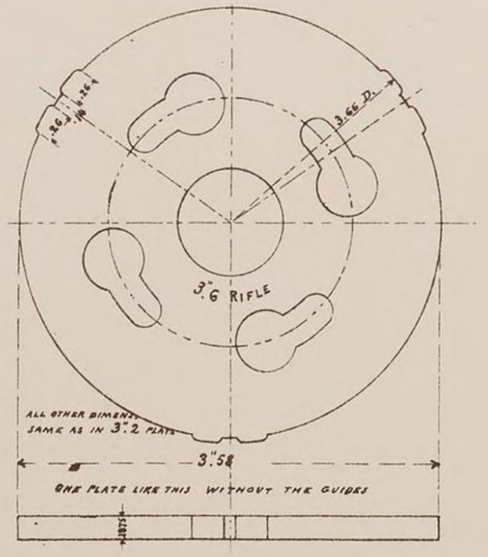
Head Supports and Rifle Guides for Star Gauge _ Model 1893

SCALE : FULL SIZE

FIG. 1







APPENDIX 19.

EFFECT OF SMALL CALIBER RIFLE PROJECTILES UPON ANIMAL TISSUE AND BONE, BY LIEUT. J. W. BENÉT, ORDNANCE DEPARTMENT, U. S. ARMY.

(23 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., August 30, 1893.

SIR: I have the honor to submit a report of experiments conducted in obedience to the following letter:

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, July 21, 1892.

SIR: I am instructed by the Chief of Ordnance to inform you that Dr. La Garde, of the Medical Department, has been appointed by the Surgeon-General to conduct a series of experiments with a .30-caliber rifle and its ammunition by firing into animals, and, if practicable, into bodies, to ascertain the effect of the new projectiles on animal tissue and bone.

The Chief of Ordnance desires that one of the officers at your post should be associated with Dr. La Garde in carrying out the experiments, and that he should prepare a report relating to the ballistic conditions of the different firings and such effects on the bullet, etc., as may be valuable to the Department. A technical medical report will, of course, be prepared by Dr. La Garde.

It is considered necessary to fire with reduced charges in certain cases, in order to simulate the firing at long distances, and certain preliminary ballistic data will probably be required; as, for instance, the remaining velocity of the bullet at 200, 500, 1,000 and 2,000 yards, and also at what may be considered the extreme range of these bullets.

Dr. La Garde will go to Frankford Arsenal and will confer fully and freely with you on the subject, and it is requested that you will arrange with him such series of experiments as he and you may deem advisable.

* * * * * * *

Directions have been given to send to you two Springfield small caliber rifles, which were directed to be made for this purpose.

Respectfully,

CHARLES SHALER,
Captain, Ordnance Dept., U. S. Army.

The COMMANDING OFFICER FRANKFORD ARSENAL.

1. OBJECT OF THE EXPERIMENTS.

It was desired to compare the effect of bullets of large and small caliber upon the same parts of the human body, at various ranges up to and including 2,000 yards.

2. Arms and Ammunition.

The arms selected were the service .45-caliber Springfield rifle and the experimental .30-caliber Springfield rifle. The cartridge for the former contains a charge of 69 grains of black powder and a hard lead bullet, cannelured and lubricated in the cannelures, weighing 500 grains; for the latter the charge used was 37 grains Wetteren smokeless powder, the bullet being of hard lead with German silver jacket, without cannelures or lubricant.

3. Use of Reduced Charges.

In similar experiments abroad, reduced charges, giving at some selected distance the same striking velocity that the bullet possesses at the required range, have been employed. Of course when the selected distance is a short one the bullet strikes nearly horizontally instead of at an angle, which may be considerable if the range simulated is a long one; the velocity of rotation is also not the same as at the actual range. With very small reduced charges the bullets do not always take the rifling properly, especially when the twist is a quick one, and strike side on or tumble. When it is desired, as in the present case, to compare the effects of two different models of bullet upon the same parts of the human body, and when the number of cadavers available for the experiments is very limited, the use of reduced charges can not be avoided, as the possibility of striking the part desired at the actual ranges in a reasonable number of shots would be extremely doubtful and success could only be attained by providing a large number of cadavers and going through long and tedious experiments. It is thought that the results obtained by the use of reduced charges may at least be considered as fair approximations to the actual results at ranges in the neighborhood of those simulated.

4. Ranges Simulated.

The ranges simulated with reduced charges were the following: 2,000, 1,500, 1,200, 800, 500, 350, 250, 150, and 100 yards. At these are found the effects corresponding to the principal zones of action. With a small-caliber rifle, having a quick twist, it was found impossible to simulate the remaining velocity obtained at greater ranges than 2,000 yards, as a charge of powder just sufficient to drive the bullet out of the bore gives a much greater velocity than is required. If the slugging of the bullet is reduced by using a rifle with an enlarged bore, or by reducing the diameter of the bullet by compression, it may be possible to obtain very low initial velocities, but they will be so irregular that no reliance can be placed upon them. Considerable irregularity was found in the velocities simulating those obtained at 2,000 yards, and occasionally the bullet would not be driven out of the bore, or would strike side on.

5. Method of Determining the Reduced Charges to be Used.

The remaining velocities at the desired ranges for the bullets of .45 and .30 caliber used were computed by the methods given in Ingalls' Exterior Ballistics. In the formula for determining the ballistic coefficient, $C = \frac{\delta_1}{\delta} \frac{w}{cd^2}$, $\frac{\delta_1}{\delta}$ was necessarily assumed as unity, and C not

being known was also assumed as unity. The correctness of the results were probably not materially affected by these assumptions. Experimental charges were tried till one was found which for a mean of 20 shots gave the velocity desired, the velocities being taken by means of two Le Boulengé chronographs, and determined at 53 feet from the muzzle of gun. A sufficient number of cartridges were then loaded with this charge and the cadaver to be fired at was placed at 53 feet from the muzzle. The velocity of the bullet on striking would be the same as that possessed by it at the end of the range simulated.

6. Computed Remaining Velocities and Striking Energies.

The remaining velocities and striking energies of the two bullets used (computed as previously explained) are given in the following table:

.45-CALIBER BULLET.

[Weight, 500 grains. Charge, 69 grains black powder. Muzzle velocity, 1,301 foot-seconds. Muzzle energy, 1,879.6 foot-pounds.]

Range.	Remaining velocity.	Striking energy.	Range.	Remaining velocity.	Striking energy.
Yards.	*Ft. secs.*	*Ft. pounds.*	*Yards.*	*Ft. secs.*	*Ft. pounds.*
17⅔	1,274	1,802.4	500	873	846.3
100	1,161	1,496.8	800	748	621.3
150	1,103	1,351.0	1,000	676	507.5
200	1,054	1,233.7	1,200	615	420.0
250	1,016	1,146.4	1,500	531	313.1
300	983	1,073.0	2,000	429	204.4
350	953	1,008.5			

.30-CALIBER BULLET.

[Weight, 220 grains. Charge, 37 grains Wetteren smokeless powder. Muzzle velocity, 2,000 foot-seconds. Muzzle energy, 1,954 foot-pounds.]

17⅔	1,957	1,871.3	500	1,103	594.0
100	1,770	1,530.9	800	898	394.0
150	1,665	1,347.2	1,000	804	315.0
200	1,567	1,199.9	1,200	729	259.6
250	1,474	1,061.7	1,500	627	192.0
300	1,387	940.0	2,000	495	120.0
350	1,304	830.8			

With the initial velocity obtained with the .30-caliber bullet, it is seen that its striking energy is greater than that of the .45-caliber bullet for the first 100 yards, after which it becomes and continues less. The ballistic coefficients of the two bullets do not differ greatly, the difference being in favor of the heavier bullet. A .30-caliber bullet, to have the same ballistic cofficient as the .45 caliber, should weigh (assuming C to be unity in both cases) about 222 grains.

7. Method of Conducting the Experiments.

The experiments were all conducted in the proof house firing gallery. The cadaver to be fired at was placed at a distance of 53 feet from the muzzle of the gun for reasons previously given, except for the 1,500 and 2,000 yard ranges, where it was found necessary, in order to record the low velocities obtained, to reduce the distance between targets to 50 feet which caused the velocity to be determined at 28 feet from the muzzle. For these ranges, therefore, the cadavers were placed at 28

feet from the muzzle. A tackle, attached to the roof beams, allowed the cadaver to be traversed so as to bring the portion desired to be struck into proper position, and a number of barrels filled with sawdust, placed one behind the other, enabled the bullet to be recovered without suffering deformation other than that received in traversing the part struck.

The bullets used were stamped on the base with a distinctive letter or number for purposes of identification. Certain bones of the body and other parts were selected by Dr. La Garde, and were fired at *in* pairs at each range, one of each pair being reserved for experiments with the .30-caliber bullet, and the other for similar experiments with the .45-caliber bullet, the object being that the effects of the two bullets upon the bone or portion selected should be produced under absolutely the same conditions. Owing to the gallery not being well lighted, more shots were fired to obtain the results desired than would have been necessary under other circumstances.

8. JOURNAL OF FIRING.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Caliber.*			
Jan. 10	100	.45	Left femur	1	Missed bone.
	100	.45	....do	2	Do.
	100	.45	....do	3	Struck lower part of left femur. Bullet shown in Pl. A.
	100	.30	Right femur.....	1	Missed bone.
	100	.30	....do	2	Struck bone. Bullet shown in Pl. A.
11	100	.45	Left thigh	4	Struck thigh. Bullet shown in Pl. A.
	100	.30	Right femur	3	Struck right femur. Bullet shown in Pl. A.
	100	.45	....do	5	Missed bone.
	100	.45	....do	6	Struck upper third of right femur. Bullet shown in Pl. A.
	100	.30	Right thigh	4	Missed bone.
	100	.30	....do	5	Do.
	100	.30	....do	6	Do.
	100	.30	....do	7	Do.
	100	.30	....do	8	Do.
	100	.45	Left humerus.....	7	Do.
	100	.45	....do	8	Struck left humerus. Bullet shown in Pl. A.
	100	.30	Right humerus ...	9	Struck middle third of right humerus. Bullet shown in Pl. A.
	100	.45	Skull	9	Struck skull. Bullet shown in Pl. A.
	150	.45	Left tibia.....	1	Guttered tibia. Bullet shown in Pl. B.
	150	.45	....do	2	Struck middle third of left tibia and fibula. Bullet shown in Pl. B.
	150	.30	....do	1	Do.
	150	.45	Right femur.....	3	Struck lower third of right femur. Bullet shown in Pl. B.
	150	.30	Left femur	2	Struck left femur. Bullet shown in Pl. B.
	150	.45	....do	4	Missed bone.
	150	.45	....do	5	Struck middle of left femur. Bullet shown in Pl. B.
	150	.30	Right femur.....	3	Missed bone.
	150	.30	....do	4	Struck right femur. Bullet shown in Pl. B.
	150	.45	Left humerus	6	Struck lower part of left humerus into elbow joint. Bullet shown in Pl. B.
	150	.30	....do	5	Missed bone.
	150	.30	....do	6	Do.
	150	.30	....do	7	Struck left shoulder joint. Bullet shown in Pl. B.
	150	.30	Right humerus...	8	Missed bone.
	150	.30	....do	9	Struck lower third of right humerus. Bullet shown in Pl. B.
	150	.45	....do	7	Missed bone.
	150	.45	....do	8	Struck right humerus. Bullet shown in Pl. B.
	150	.30	Skull	0	Struck skull. Bullet shown in Pl. B.

8. JOURNAL OF FIRING—Continued.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Caliber.*			
Jan. 12	250	.45	Left tibia.....	1	Struck lower third of left tibia. Bullet shown in Pl. C.
	250	.30	Right tibia	1	Struck right ankle. Tibia and fibula not injured. Bullet shown in Pl. C.
	250	.45	Left knee femur ..	2	Struck left knee joint. Bullet lost.
	250	.30	Right tibia	2	Struck too high.
	250	.30	....do	3	Struck head of right tibia. Bullet shown in Pl. C.
	250	.45	Left hip joint.....	3	Struck left hip joint. Bullet shown in Pl. C.
	250	.30	Right hip joint ...	4	Struck right hip joint. Bullet shown in Pl. C.
	250	.30	Left elbow.....	5	Struck too low.
	250	.30	....do	6	Struck radius and ulna of left side. Bullet shown in Pl. C.
	250	.30	Right elbow	7	Struck right elbow joint. Bullet shown in Pl. C.
	250	.45	Left humerus.....	4	Struck lower third of left humerus. Bullet lost.
	250	.45	....do	5	Did not strike bone.
	250	.45	....do	6	Struck left shoulder joint. Bullet lost.
	250	.30	Right humerus ...	8	Struck right humerus. Bullet shown in Pl. C.
	250	.30	Forehead	9	Struck forehead. Bullet lost.
	350	.30	Left ankle joint ..	1	Struck too low.
	350	.30	....do	2	Struck left ankle. Bullet shown in Pl. D.
	350	.45	....do	1	Struck tibia near ankle.
	350	.45	....do	2	Struck left ankle. Bullet shown in Pl. D.
	350	.30	Right ankle joint.	3	Struck too low.
	350	.30	....do	4	Struck right foot. Bullet shown in Pl. D.
	350	.30	Left tibia	5	Struck left tibia and fibula near knee joint. Bullet shown in Pl. D.
	350	.45	Left ankle joint ..	3	Struck left ankle joint. Bullet shown in Pl. D.
	350	.30	Right hip joint...	6	Struck right hip joint. Bullet shown in Pl. D.
	350	.30	Left hip joint.....	7	Struck left hip joint. Bullet shown in Pl. D.
	350	.30	Left elbow joint..	8	Grazed elbow.
	350	.30	....do	9	Struck rib.
	350	.30	....do	0	Did not strike bone.
	350	.30	....do	B	Not satisfactory.
	350	.30	Right elbow joint.	E	Struck right elbow joint. Bullet shown in Pl. D.
	350	.45	Right humerus...	4	Struck too high.
	350	.45	....do	5	Struck too far to left.
	350	.45	....do	6	Struck right humerus. Bullet lost.
	350	.30	Left humerus.....	K	Struck left humerus. Bullet shown in Pl. D.
	350	.30	Skull	D	Struck nose. Bullet shown in Pl. D.
Feb. 8	500	.45	Left tibia.....	1	Struck left tibia. Bullet shown in Pl. E.
	500	.30	Right knee	1	Struck right knee. Bullet shown in Pl. E.
	500	.45	Left femur	2	Struck left femur. Bullet shown in Pl. E.
	500	.30	Right femur	2	Struck right femur. Bullet shown in Pl. E.
	500	.30	Pelvic bones.....	3	Struck upper third of right femur. Bullet shown in Pl. E.
	500	.30	....do	4	Satisfactory. Bullet shown in Pl. E.
	500	.45	Left humerus.....	3	Struck left humerus. Bullet shown in Pl. E.
	500	.30	Right elbow	5	Struck too low.
	500	.30	....do	6	Struck too low and to the left.
	500	.30	....do	7	Struck right elbow joint. Bullet shown in Pl. E.
	800	.45	Left shoulder.....	1	Struck a little high. Bullet shown in Pl. F.
	800	.45	....do	2	Not satisfactory.
	800	.30	Right shoulder ...	1	Not satisfactory. Too low.
	800	.30	....do	2	Do.
	800	.30	....do	3	Do.
	800	.30	....do	4	Grazed shoulder.
	800	.30	....do	5	Struck right shoulder joint. Bullet lost.
	800	.30	....do	6	Not satisfactory.
	800	.30	Skull	7	Struck skull. Bullet shown in Pl. F.
Mar. 8	500	.45	Left knee.....	A	Struck left knee joint.
	800	.45	Left tibia.....	3	Not satisfactory.

8. JOURNAL OF FIRING—Continued.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Caliber.*			
Mar. 8	800	.30	Right tibia	A	Penetrated bone without shattering. Bullet shown in Pl. F.
	1,200	.45	Right knee	1	Struck right knee. Bullet shown in Pl. G.
	1,200	.45	Left femur	2	Struck upper third of left femur. Bullet shown in Pl. G.
	1,200	.30	Right femur.....	1	Struck upper third of right femur. Bullet shown in Pl. G.
	250	.45	Left shoulder joint	0	Struck left shoulder. Bullet shown in Pl. L.
	500	.45	Left hip joint.....	4	Struck left hip joint. Bullet lost.
	350	.45	Left elbow.....	K	Struck left elbow joint. Bullet shown in Pl. L.
	800	.45	Right shoulder ...	J	Struck right shoulder. Bullet not deformed.
	800	.30	Right elbow	B	Struck too low. Bullet shown in Pl. F.
	800	.30	....do	F	Do.
	800	.30	....do	K	Struck right elbow joint. Bullet shown in Pl. F.
	250	.45	Skull	8	Struck skull. Bullet shown in Pl. L.
9	1,500	.45	Left humerus.....	1	Not satisfactory.
	1,500	.45	.....do	2	Do.
	1,500	.30	Right humerus ...	1	Do.
	1,500	.30	.....do	2	Do.
	1,500	.30	.....do	3	Do.
	1,500	.30	.....do	4	Struck too low. Bullet shown in Pl. H.
	1,500	.30	.....do	E	Not satisfactory.
	1,500	.45	Left humerus.....	3	Struck lower third of left humerus. Bullet shown in Pl. H.
	1,500	.30	Right elbow	H	Struck too low.
	1,500	.30	.....do	D	Struck lower shaft of right humerus. Bullet shown in Pl. H.
	1,500	.30	Left hip joint.....	G	Struck left hip joint. Bullet shown in Pl. H.
	1,500	.45	Right hip joint ...	5	Struck too high.
	1,500	.45	.....do	6	Struck bone. Bullet lodged.
	1,500	.45	Left femur	7	Struck upper third of left femur. Bullet broke up and pieces lodged.
	1,500	.30	Right femur	A	Not satisfactory.
	1,500	.30	.....do	5	Struck right humerus. Bullet lost.
	1,500	.30	Left femur.....	6	Struck left femur at middle third. Bullet shown in Pl. H.
	800	.45	Skull	A	Struck skull.
	1,200	.45	Left femur.....	J	Struck lower third left femur.
	1,200	.30	Right tibia	K	Struck head of right tibia. Bullet shown in Pl. G.
	1,200	.30	Right femur	D	Struck lower end of right femur. Bullet shown in Pl. G.
	1,200	.45	Left knee.....	B	Struck left knee joint. Bullet shown in Pl. G.
	1,200	.45	Left tibia.....	G	Struck left tibia and fibula near ankle joint. Bullet shown in Pl. G.
	1,200	.30	Right tibia	H	Struck right tibia near ankle. Bullet shown in Pl. H.
16	2,000	.45	Left tibia.....	I	Struck left tibia, middle third. Bullet broke up and lodged.
	2,000	.30	Right tibia	I	Did not strike bone.
	2,000	.30	....do	2	Bullet missed and struck side on.
	2,000	.30	....do	3	Did not strike bone.
	2,000	.30	....do	4	Struck right tibia side on.
	2,000	.45	Left knee.....	2	Struck left knee joint. Bullet lost.
	2,000	.30	Right knee	5	Missed bone.
	2,000	.30	....do	6	Do.
	2,000	.30	....do	7	Do.
	2,000	.30	....do	8	Do.
	2,000	.30	....do	9	Struck right knee joint. Bullet shown in Pl. J.
	2,000	.45	Left femur.....	3	Struck upper third of left femur. Bullet shown in Pl. J.
	2,000	.30	Right femur	0	Struck upper third of right femur. Bullet shown in Pl. J.
	2,000	.45	Left humerus.....	4	Struck left humerus. Bullet shown in Pl. J.
	2,000	.30	Right humerus ...	A	Did not strike bone.
	2,000	.30	....do	H	Was not expelled from barrel.
	2,000	.30	....do	E	Did not strike bone.
	2,000	.30	....do	G	Do.

8. Journal of Firing—Continued.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Caliber.*			
Mar. 16	2,000	.30	Right humerus...	F	Did not strike bone.
	2,000	.30	....do	J	Do.
	2,000	.30	....do	D	Do.
	2,000	.30	....do	T	Do.
	2,000	.30	....do	B	Struck too low.
	2,000	.30	....do	K	Struck right humerus. Bullet shown in Pl. J.
18	2,000	.45	Left arm.....	1	Grazed arm.
	2,000	.45	....do	2	Missed bone.
	2,000	.45	....do	3	Struck bone.
	2,000	.45	....do	4	Do.
	2,000	.30	Right arm	1	Passed between body and arm.
	2,000	.30	....do	2	Did not strike bone.
	2,000	.30	....do	3	Do.
	2,000	.30	....do	4	Do.
	2,000	.30	....do	5	Do.
	2,000	.30	....do	6	Do.
	2,000	.30	....do	7	Do.
	2,000	.30	....do	8	Do.
	2,000	.30	....do	9	Struck bone; bullet lost.
	2,000	.45	Left arm.....	5	Struck bone.
	2,000	.30	Right tibia.....	E	Did not strike bone.
	2,000	.30	....do	N	Do.
	2,000	.30	....do	F	Shattered bone.

Date.	Range.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Feet.	*Caliber.*			
Mar. 18	53	.45	Left humerus	3	Full charge used. Struck left shoulder joint. Bullet shown in Pl. K.
	53	.45	....do	4	Struck left humerus at junction of middle and lower thirds. Bullet shown in Pl. K.
	53	.30	Right humerus ...	9	Struck right humerus, shaft above the middle. Bullet shown in Pl. K.
	53	.45	Left tibia.....	5	Struck left tibia, middle third. Bullet shown in Pl. K.
	53	.30	Right tibia	F	Struck right tibia. Bullet shown in Pl. K.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Caliber.*			
Mar. 25	1,500	.30	Right humerus...	1	Not satisfactory
	1,500	.30	....do	2	Do.
	1,500	.30	....do	3	Do.
	1,500	.30	....do	4	Do.
	1,500	.30	....do	5	Struck right humerus. Bullet lost.
	1,200	.30	Right arm	E	Not satisfactory.
	1,200	.30	....do	B	Do.
	1,200	.30	....do	J	Do.
	1,200	.30	....do	A	Do.
	1,200	.30	....do	6	Do.
	1,200	.30	....do	7	Do.
	1,200	.30	....do	8	Do.
	1,200	.30	....do	K	Struck middle third right ulna.
	1,500	.30	Left humerus.....	9	Struck too low.
	1,500	.30	....do	0	Struck left humerus junction of upper and middle thirds. Bullet shown in Pl. M.
	1,200	.30	....do	P	Did not strike bone.
	1,200	.30	....do	R	Do.
	1,200	.30	....do	S	Struck left radius middle third. Bullet shown in Pl. M.
	1,500	.30	Left femur.....	6	Struck left femur middle third.
	1,200	.30	Left tibia.....	N	Struck middle of shaft of left tibia. Bullet shown in Pl. M.

8. JOURNAL OF FIRING—Continued.

Date.	Range simulated.	Bullet used.	Portion of body aimed at.	Mark on bullet used.	Remarks.
	Yards.	*Coliber.*			
Mar. 25	1,200	.30	Left tibia.....	M	Struck head of left tibia. Bullet shown in Pl. M.
	1,200	.30	....do	Q	Struck left tibia near ankle. Bullet shown in Pl. M.
	1,200	.30	Right tibia	C	Struck right tibia near ankle joint. Bullet shown in Pl. M.
	1,200	.30	....do	T	Struck middle of shaft of right tibia. Bullet shown in Pl. M.
	1,500	.30	Right knee	7	Struck right knee joint. Bullet shown in Pl. M.
	1,500	.30	Right femur	8	Struck right femur, middle third. Bullet shown in Pl. M.

The details of the wounds inflicted in the above firing are minutely given in Dr. La Garde's very exhaustive technical medical report. Plates A to M, inclusive, showing bullets which inflicted characteristic wounds, arranged in groups corresponding to the different ranges, are from photographs taken by First Lieut. William C. Wren, Seventeenth Infantry. Plates 1 to 11, showing the effects upon certain characteristic bones produced by the .30-caliber bullet and the ordinary and extraordinary deformations of this bullet, are from photographs made by direction of Dr. La Garde, and form part of his report.

9. COMPARISON OF WOUNDS INFLICTED BY THE TWO BULLETS.

(*a*) ZONE OF EXPLOSIVE EFFECT.*

Foreign experimenters differ widely as to the extent of the zone of explosive effect with small caliber bullets. Thus Bovet does not note explosive effects. Bircher limits the zone to 400 meters with the Rubin copper-jacketed bullet, the jacket of which often stripped on striking. Delorme met explosive effects up to 200 and 300 meters with the Lebel bullet, which Chauvel in his experiments was unable to duplicate.

The varying conditions under which experiments are carried on, the more or less deformability of the bullet used, and the differing circumstances of impact, easily explain why discrepancies should occur. In the experiments here the zone of explosive effect was observed to extend to 350 yards with the .30-caliber bullet, and only to 250 yards with that of .45 caliber. Where these effects were noted with the small caliber bullet it was generally found that it was badly deformed, and that the jacket had been wholly or partially stripped off; still cases did occur in which the bullet was little deformed or not at all. It is safe to state, however, that with an undeformable bullet the occurrence of explosive effects will be less frequent, and possibly the extent of the zone very much reduced. The nickeled steel-jacketed bullet, experimented with here subsequently to these experiments, was not deformed in the least after penetrating sand and hard oak, where the German silver-jacketed bullet was broken up completely.

The use of such a bullet as the former would no doubt greatly diminish explosive effects, though it must be remembered that these are only met with at the short ranges and did not, as before mentioned, extend beyond 350 yards in the experiments here.

* See Appendix, notes A and B.

When the muscular parts alone are struck explosive effects were not observed with the small caliber bullet.

(*b*) ZONE OF PERFORATION.

The effect of the small caliber bullet upon the bones was not as severe as that of the .45 caliber; there was less shattering, and sometimes complete perforation of the bone with little or no splintering, as is shown in some of the plates. In the joints and soft parts the wounds inflicted by the small caliber bullet were less severe, and partook of the nature of subcutaneous wounds.* The bullet was rarely much deformed.

The effects noted at 2,000 yards were more severe than at the preceding ranges in the zone of perforation. This was probably due to the small powder charge used in simulating the 2,000-yard range, which was doubtless not sufficient to give the bullet the proper rotation. Several bullets struck side on, and one of these lodged on striking—the only case recorded for a .30-caliber projectile. The rarity with which the small caliber bullets stop in the body has been commented upon by all experimenters.

(*c*) ZONE OF CONTUSION.

For reasons previously given, the results obtained in this zone could not be simulated. Bullets which preserve little more than their motion of rotation generally do not make an open wound, but a contusion of variable depth. Chauvel remarks that jacketed bullets have more tendency to penetrate than to simply contuse the teguments and adjacent tissues. At long ranges it has been frequently remarked that wounds are often more severe than at the mid ranges. When the projectile begins to lose its stability of rotation it is evident that its "wabbling" will have an important effect on the wound made; the increased striking angle also must be considered.

(*d*) SUMMARY.

By the substitution of the small caliber bullet for the one now in service the severity of the wounds inflicted is greatly lessened, and on humanitarian grounds the change of caliber is to be desired. The severity of wounds at short ranges will be further lessened by the adoption of a small caliber bullet, seldom or never deformable at the highest striking velocities against the hardest human bones. A bullet to fulfill these condition must be furnished with a steel jacket.

Some of the above results may seem at variance with certain foreign statements. It must be remarked that the large caliber projectile used on the continent of Europe in comparison with their 7.5 and 8 mm. bullets is 11 mm. caliber, and is more than a hundred grains less in weight than our 500-grain .45-caliber bullet. Its resistance to deformation being about the same, and its striking energy much less, the wounds inflicted by it would not be so severe. Some foreign experiments conducted in France and England, in which the effects on bones of the small caliber bullet were stated to be appalling, were made on horse bones, which are more resistant than human ones and break up a projectile more easily.

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* See note C, Appendix.

10. Stopping Effect.*

The stopping effect of a bullet, or the shock produced by it, seems to depend on the loss of energy experienced by the bullet in its passage through the body. Thus a bullet which does not deform will often have less stopping effect than one with less striking energy which deforms considerably and emerges from the body with a considerable loss of energy. Especially will this be so with flesh wounds. When a bone is struck, even if a clean perforation is made, it may be assumed that the shock will be sufficient to permanently disable the man struck. With flesh wounds it is otherwise. Surgeon Parry Marsh, of the English medical staff, records two cases of accidental injury from .30-caliber bullets. In the first case the man struck was 1 mile and 800 yards from the firing point, and was shot through the fleshy part of the right thigh, the bullet having ricocheted twice before striking. It was picked up, and found to be undeformed. The man did not fall when struck, nor did he know he was seriously hurt. In the second case the man struck was 100 yards distant from the firer, the bullet passing through the flesh of the thigh without touching the bone. He was not knocked down by the blow, nor were there any serious symptoms, such as shock. The assumption is that the bullet did not deform materially.

It is safe to say that the stopping effect of the .30-caliber bullet is less than that of the .45 caliber, except, perhaps, at very short ranges, when the bullet is much deformed on striking. An undeformable bullet will have less stopping effect than a deformable one. This inferiority makes the bullet less efficient in this connection at short ranges, and whether it is to be trusted to repel a charge of cavalry can only be determined by experience in actual warfare.

It may be presumed that even flesh wounds, received at long ranges, will eventually disable the soldier so that he can not be brought up to the critical zone of the combat.

Small caliber bullets, having the jacket removed at the point so as to expose the lead, have been recently tried in Germany and Roumania, the object being to make the bullet mushroom on striking, thus increasing its frontage and giving more shock. When the caliber of the rifle is reduced to 6.5 mm, as in the Roumanian Mannlicher, or still lower, as advocated by Prof. Hebler, a modification of this kind would be more necessary than with the 7.62 mm. (.30 caliber) rifles. To sum up, the undeformable small caliber bullet is much superior on the score of humanity, but has less stopping power than the one which mushrooms, deforms, or breaks up on striking. Whether the stopping power of the former is sufficient actual experience is necessary to determine, and it may be concluded that if found lacking in this important requisite it will not be retained on the score of humanity.

Respectfully, etc.,

J. W. Benét,
First Lieutenant, Ord. Dept., U. S. Army.

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* See note D, Appendix.

APPENDIX.

NOTE A.—ZONES OF ACTION.

Four zones of action are generally accepted for large caliber bullets. (1) Zone of explosive action, sometimes called zone of hydraulic pressure; (2) zone of loss of substance; (3) zone of rupture or tearing; (4) zone of contusion. They are described as follows in Chauvel and Nimier's "Traité Pratique de Chirurgie d'Armeé:"

(1) Zone of explosive action.

The term zone of explosive action seems preferable to that of zone of hydraulic pressure. The characteristics of wounds received in this zone are the following: An orifice of entrance usually small but sometimes torn, an opening of exit wide and jagged with large cutaneous and muscular shreds attendant, and a conical channel whose walls are formed by tissues torn and crushed as if burst from an enormous pressure acting outwards from the inside.

If a bone is struck the destruction is enormous, the wound of exit frightful in size and irregularity. Sometimes fragments are thrown out to a distance of 10 to 15 meters on all sides, but chiefly in the rear of the parts struck.

It is principally at close ranges of 10 to 15 meters that this frightful destruction is observed. With lead bullets the phenomenon occurs up to 200 or 300 meters according to the parts struck, but to carry this zone up to 800 and 1,000 meters with Reger seems to be an exaggeration. Five hundred meters may be fixed as an extreme limit for lead bullets.

For the large bones, the brain, and the stomach the distance is less than for parts like the heart or the bladder distended with blood or urine. Beyond 300 meters typical lesions are exceptional.

It is a fact, whatever theory may be advanced to account for it, that bullets animated with high velocity produce up to a certain distance and under certain conditions wounds of special character; that this action, called explosive, increases with the volume, the weight, and the energy of the bullet; that deformation of the point aggravates these characters by increasing the surface acting; that this property common to modern arms is exercised up to a distance which increases with the initial velocity, and for soft lead bullets reaches 200, 300 meters, and further. If the velocity of rotation and translation plays the principal rôle in the production of explosive effects, these phenomena, in spite of the diminution of weight, caliber, and surface of metal-jacketed bullets and their habitual nondeformation, will be sometimes observed with the new small-caliber projectiles. They were noticed in 1887 with steel-jacketed bullets, though Bovet, firing at 10 meters with full charges upon animal carcasses and human skulls, did not remark them.

All the orifices of entrance and exit in the bones of the skull, as in the soft parts, presented small dimensions.

There was no stripping with the Hebler steel-jacketed bullet.

The Rubin copper-jacketed bullet, under the same conditions, produced manifestly explosive effects in Bircher's experiments, and he limits to 400 meters the zone of explosive effects for the bones with that bullet, and thinks that for the Hebler steel-jacketed bullet it ought to be the same, the less deformation and the smaller caliber compensating for the increased velocity.

Delorme met explosive effects up to 200 meters with the Lebel bullet. We have not obtained such satisfactory results, and it is only in firing at 10 meters or less with full charges that we have established a truly frightful destruction.'

It seems then to result from experiment that in spite of their greater velocity of translation and rotation the small-caliber bullet, non or little deformable, furnished with a resisting envelope, does not possess the same extent of explosive action as deformable lead bullets; for them the phenomenon of explosion seems limited to 200 or 300 meters distance, which is true of the skull as well as the large bones of a man.

(2) *Zone of loss of substance.*

Certain tissues, the skin, the muscles, etc., do not offer favorable conditions to explosive action. Submitted to the action of high-velocity bullets they are perforated as with a punch, and suffer a loss of substance bearing a relation to the caliber of the bullet.

This zone extends from 400 to 1,000 meters and often farther, according to the velocity. The epiphyses are crossed by a narrow regular channel containing scarcely any bone dust, while the skin presents a regular round hole.

The bullet in its rapid passage carries away everything which has opposed it, not allowing the elasticity of the tissues time to enter into action. The walls of the channel are clean and regular, without trace of crushing. Only the compact bones offer a pronounced breaking up and behind them is sometimes found a traumatic "foyer" quite extended and containing some splinters. The small-caliber bullets, by reason of their resistance to deformation and their velocity, exercise in the soft tissues and the epiphyses this perforating action up to considerable distances. Bircher estimates that it may be produced at 1,400 and up to 1,500 meters, and it may be carried farther yet.

(3) *Zone of rupture and tearing.*

With lead bullets this zone, giving from 1,000 to 1,600 meters, and sometimes farther, answers to the greatest number of wounds. The type of these lesions is for compact bones, perforation, complete or incomplete, with the great splinters so well described by Delorme, sometimes also with projection of fragments toward the hole of exit or towards the traumatic "foyer." In the epiphyses and soft parts the path tends toward the conical form, if the bullet has followed a rectilinear course. At the entrance the skin is perforated by a narrow orifice, round or fissured, with clean edges. The fibrous tissues show a narrow slit, the muscles a channel wider than the bullet. The walls are contused and torn. At the exit the skin is raised and star-shaped; it has yielded under the pressure of the point of the bullet, and stretched strongly it has been torn into divergent strips.

Perhaps at these long ranges the rotation of the bullet acts laterally to throw aside the parts. When the bullet is deformed by a bone, or deviated by a bone or tendon, its course ceases to be rectilinear, and presents more irregularity in its caliber and aspect. Under these conditions the lodging of the bullet occurs not rarely, and it remains in contact with a bone or is lost in the flesh. At this point is found the broadest part of the channel of the bullet. The channels made in this zone are wide with jagged edges. Is it the same with jacketed bullets? Delorme seems to think so; we do not. If diaphysary perforations have

been found in the compact bones up to 2,000 meters, fractures by simple contact are rare in our experience. Cutaneous perforations and muscular setons have not presented to us those wide conical channels with torn walls, types of this zone of rupture.

(4) *Zone of contusion.*

This extends to the fall of the bullet and its definite stoppage—up to 2,400 or 3,000 meters with the new bullet.

Spent bullets do not make an open wound but a contusion of variable depth. Fissures or simple fractures may also result from spent bullets. Jacketed bullets have more tendency to penetrate than to simply contuse the teguments and adjacent tissues.

LEAD AND JACKETED BULLETS.

In practice the division into zones is not important. The zones are often confounded, and in the same wound the lesions of the bones do not always belong to the same type as those of the soft tissues. Outside of the two extreme zones of explosion and contusion the distinction is often impossible even with deformable lead bullets. It is the same and to a much higher degree with jacketed bullets. For the latter only three zones can generally be distinguished—explosion, perforation, and contusion—when the soft parts and bones are considered. The first zone is very limited for soft tissues, but has for the diaphyses and skull a somewhat greater extent. What dominates in the new bullet is the power of perforation, which reunites these conditions—small caliber and elongated form, absence of deformation, velocity of translation, and a more considerable rotation.

NOTE B.—EXPLOSIVE EFFECTS.

The principal characteristics of these wounds are given in note A. Their frightful character has led to the charge in several modern wars of the employment of explosive bullets. This charge was further supported by the grayish tinge of the flesh, as if burnt by an explosion, which sometimes occurs. This, however, is probably caused by some of the lead being pulverized and volatilized by the shock and deposited on the neighboring flesh.

Various ingenious theories have been promulgated to account for the phenomena noted, which may be briefly mentioned.

(1) *Action of air and powder gas.*

Melsen, Laroque, and Neudörfer claim that the bullet drives a column of compressed air before it, which enters the tissues, distends them, and produces rupture. Busch suggests that the effects may be due to the entrance of powder gas with the bullet, a theory which is not tenable, as they are noted at distances to which powder gases could not attain. Melsen's theory is hardly more probable.

(2) *Action of fusion.*

Richter, Müller, etc., held that lead bullets on striking were heated to fusion and drops of melted lead distributed, destroying the tissues. Hagenbach stated that the temperature of a bullet with 400 meters

velocity is, from the theory of heat, 582° C. when it is stopped suddenly, and as the melting point of lead is 334°, every bullet which flattens against a human bone must cauterize the tissue. Melsen disproved this by experiments which showed no fusion of the lead, and Beck by picking up bullets immediately after striking and plunging them into mercury. Even when the bullets encountered resistance from three to four times greater than that of the human body, the temperature resulting did not exceed the following: 11 mm. lead bullet, 69° C.; 7.5-inch steel jacketed bullet, 78° C.; 7.5-inch copper jacketed bullet, 110° C.

It was also shown by Kocher that the detached particles of lead have a limited sphere of action, and admitting the fusion to take place, it would not explain the explosive effects observed.

(3) *Action of hydraulic pressure.*

Kocher and Reger hold that a high-velocity bullet striking organs and viscera more or less penetrative with liquids communicates motions to the latter, producing a hydraulic pressure and the destructive effects noted. Delorme objects that this theory requires the presence of soft tissues and liquids; high velocity for the bullet, so that the liquid contents has not time to escape by the natural openings or hole of entrance, and the existence of an envelope dense and resistant enough not to be distended by pressure. Now, explosive effects are remarked when all of these conditions do not obtain.

(4) *Effect of velocity of rotation of the bullet.*

The bullet's velocity of rotation no doubt has its effect in producing severe wounds. Laure and Kocher, in their experiments upon wood, state that the cylindro-conical projectiles when recovered were surrounded by a mass of wood which was not found on the spherical bullets. In firing against clay, which resembles animal tissues, the rotative effects were preserved and found to be remarkable. Of course in penetrating a body the bullet has not time to make a complete turn about its axis, but a partial turn will produce a very considerable result.

(5) *Theory of contusion.*

This theory, which seems to give the most probable explanation, is thus stated by Delorme:

The greater the velocity of the bullet the more it acts as a punch. The portions of the tissues which are detached, animated by a portion of its energy, slide over it and are projected against the walls of the channel, the contusions and lacerations of which are considerably augmented. Elastic and resisting tissues offer a momentary obstacle to the passage of the bullet; they are then thrown aside, traversed, not without having suffered a shock which is propagated to a distance. Each stoppage of the bullet by a resisting or elastic part, however short or instantaneous, allows the velocity of rotation to exercise more completely its effects upon the same point, to increase the projection of the tissues and the diameter of the channel. A bullet, on the contrary, animated by a relatively low velocity while still behaving as a punch, as the orifice of entrance shows, does not act so violently. Often the tissues are made to burst after having been stretched to the limit of their extension. The projection of detached parcels of tissues against the walls of the channel is so feeble that it may be neglected,

and the destruction is much more limited than when the bullet has a more considerable remaining velocity.

Bullets in the great majority of cases act in two ways: First, by producing direct attrition of the tissues; second, by producing indirect attrition of the tissues.

The first is the action of the bullet itself, the second is the effect of the rapid communication of the energy of the bullet to the solid or liquid molecules it displaces. When the bullet has a low velocity the phenomena of direct attrition is superior to that of indirect attrition. With bullets possessing a great energy the reverse is produced and the destruction is proportional to the remaining velocity of the bullet.

Vast excavations are sometimes hollowed out at the expense of the tissue of a whole region. The holes of entrance of these cavities preserve their diameter and habitual form, but the orifices of exit are immense—up to 15 and 20 centimeters diameter. These are usually produced by the bullet striking a bone, where the projection of the splinters or the breaking up of the bullet explains the disorders. But sometimes the bullet strikes the soft parts. It suffices to produce this effect to fire at short distances with high velocities at regions rich in tendinous masses and in thick oponeurosotic lames. The enormous energy that the projectile communicates to the liquid or solid molecules that it meets accounts for all disorders observed.

NOTE C.

Dr. La Garde quotes Habart, an Austrian authority, as follows:

The blood vessels are seldom torn, and are not closed so easily by coagulation as those severed by leaden projectiles. The latter are more apt to bruise and lacerate the blood vessels, facilitating thereby the formation of thrombi. On account of the smaller aperture in the skin and soft parts the wounds bleed generally less than those made by the soft leaden bullets; the hemorrhage is easily stopped by coagulation.

But Surg. Capt. Nichols, of the English army, states:

The absence of bruising and laceration carries with it a danger of its own. The comparative rarity of severe bleeding on the field of battle is well known to be due to the crushing to which the tissues, and with them the blood vessels, are subjected; and I see no reason to doubt that a bullet which can punch a clean hole through a man's thigh would do the same to any large vessel in its path. The hard, sharp, elongated bullet, at its high rate of speed, will cut like a knife, and this means bleeding and death.

NOTE D.

Capt. Monbrison, of the French army, in a recent article notes that in the Dahomey war the Lebel bullets did not always stop the rush of the enemy, and that often severe wounds did not at once incapacitate the Dahomeyans for further fighting. It must be remembered, however, that the same thing occurred in the Soudan, where the English used the large caliber Martini-Henry rifle.

Racial characteristics differ, and it is dangerous to draw inferences with regard to civilized combats from data accumulated in warfare with savage tribes.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 12, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army, in accordance with his instructions dated July 21, 1892.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

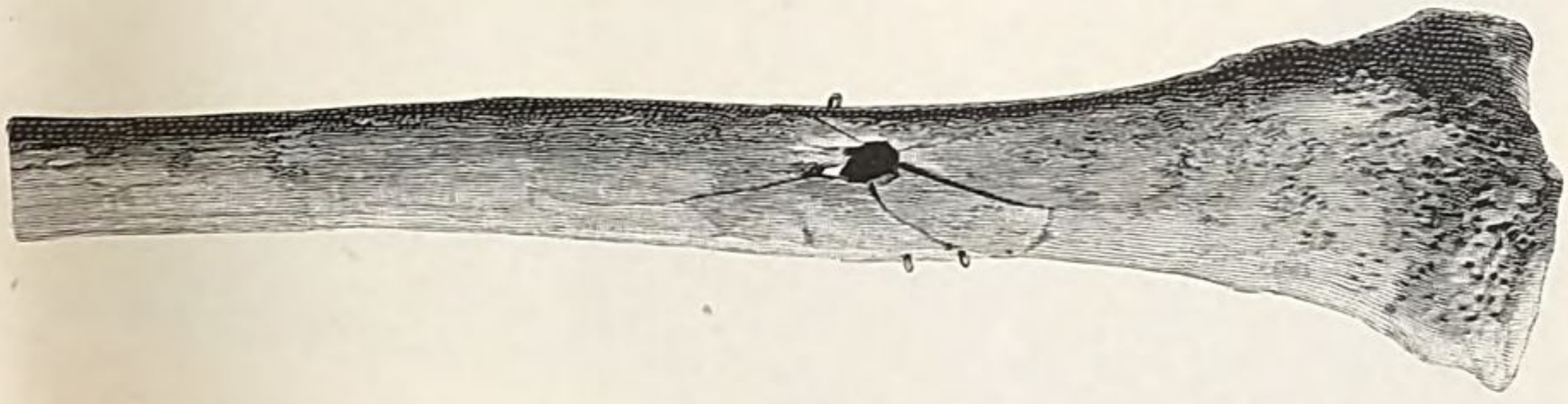


FIG. 1. Gunshot injury of the right tibia, at the junction of the upper and middle thirds, by the .30-caliber German silver jacketed projectile with the velocity common at 1,200 yards. The projectile penetrated the shaft 6 inches below the knee joint. Examination immediately after the shot was fired revealed no mobility, although upon dissection a distinct fracture was observed. The displacement of the principal fragments is very slight.

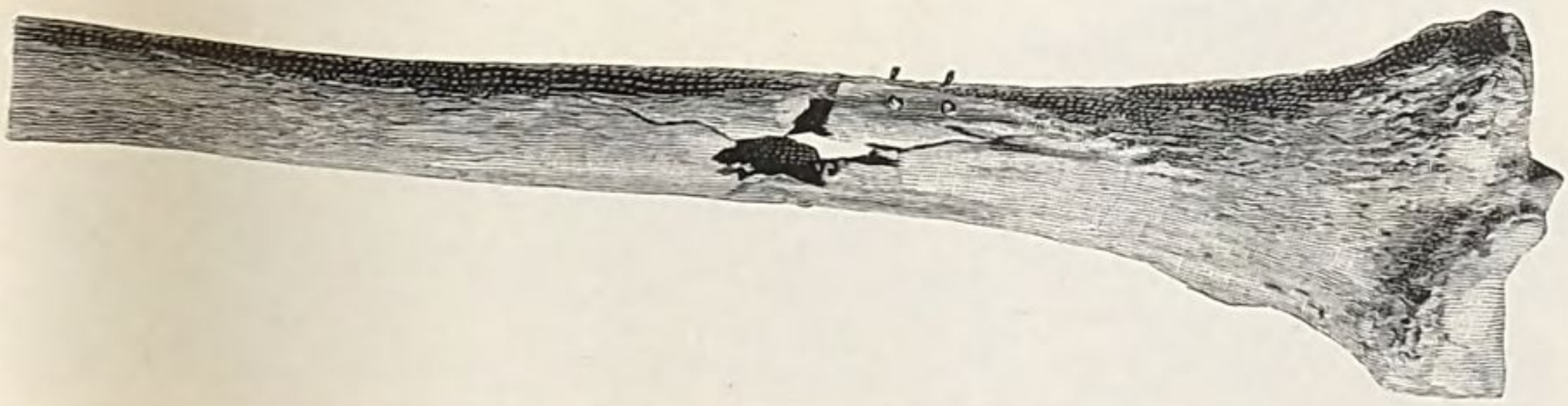


FIG. 2. A posterior view of Fig. 1.

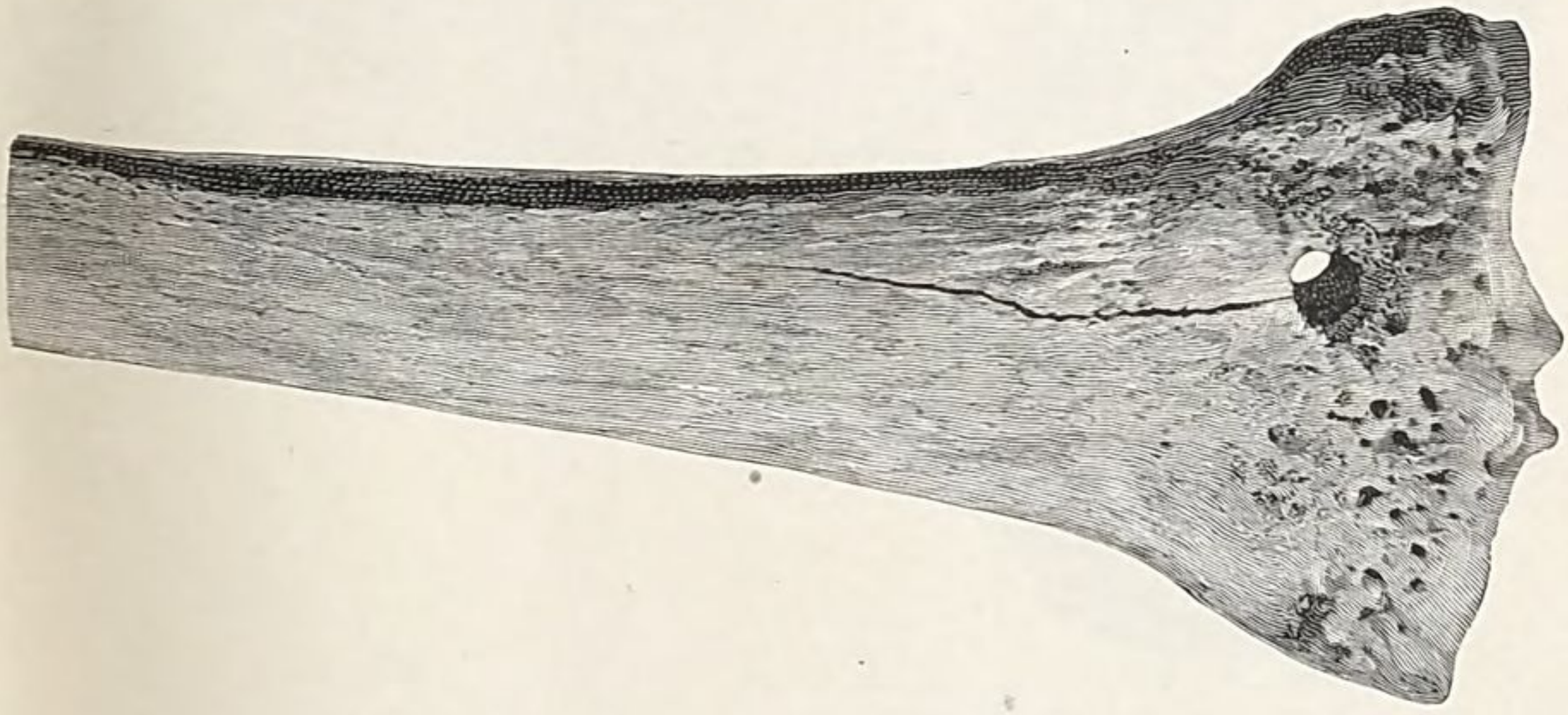


FIG. 1. Gunshot injury of the head of the right tibia by the .30-caliber German silver jacketed projectile with the velocity common at 1,200 yards. The projectile perforated the head of the tibia in the middle line, 0.39 inch below the articular surface. The diameter of the track of the bullet in the bone corresponds to the diameter of the missile.

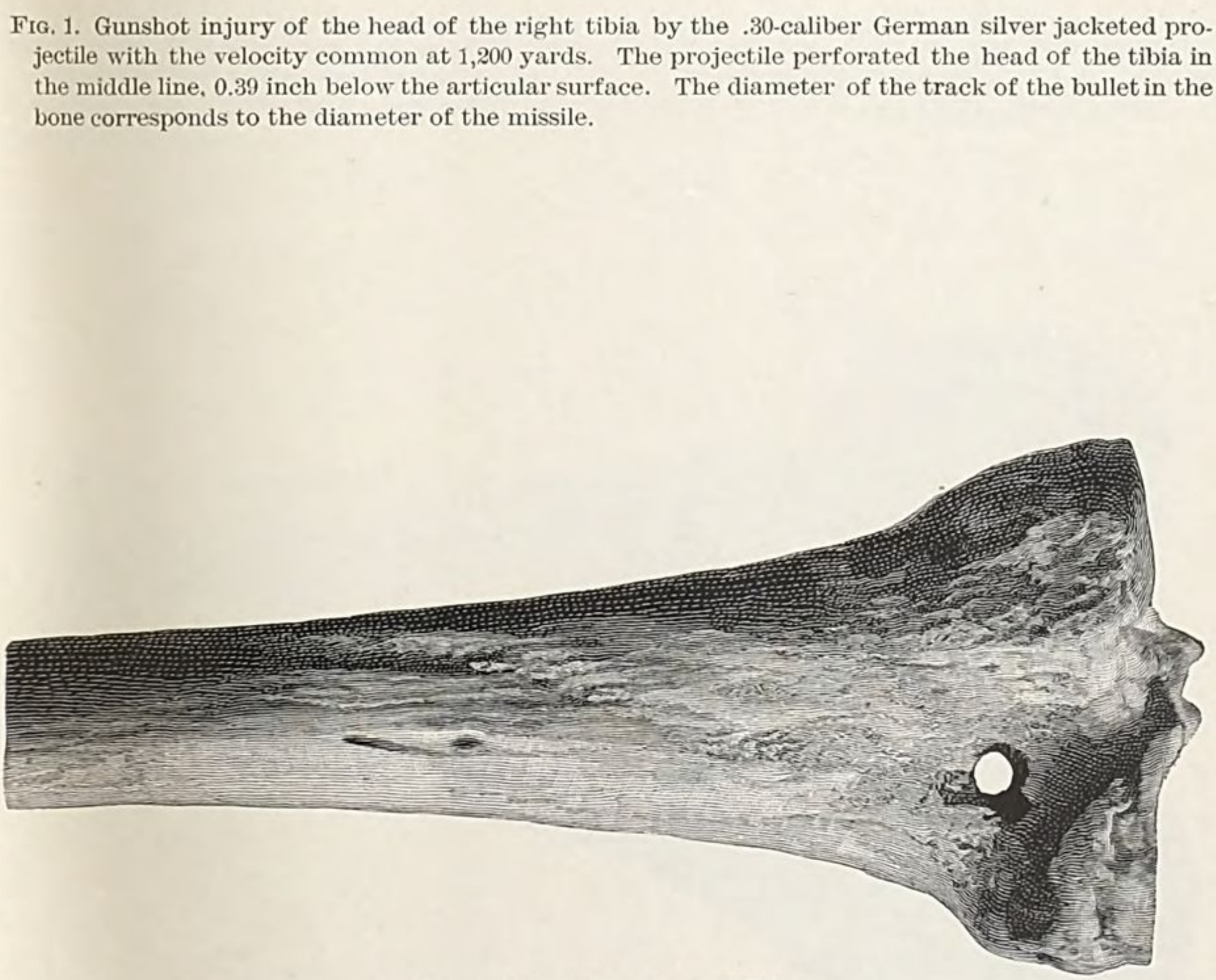


FIG. 2. A posterior view of Fig. 1.

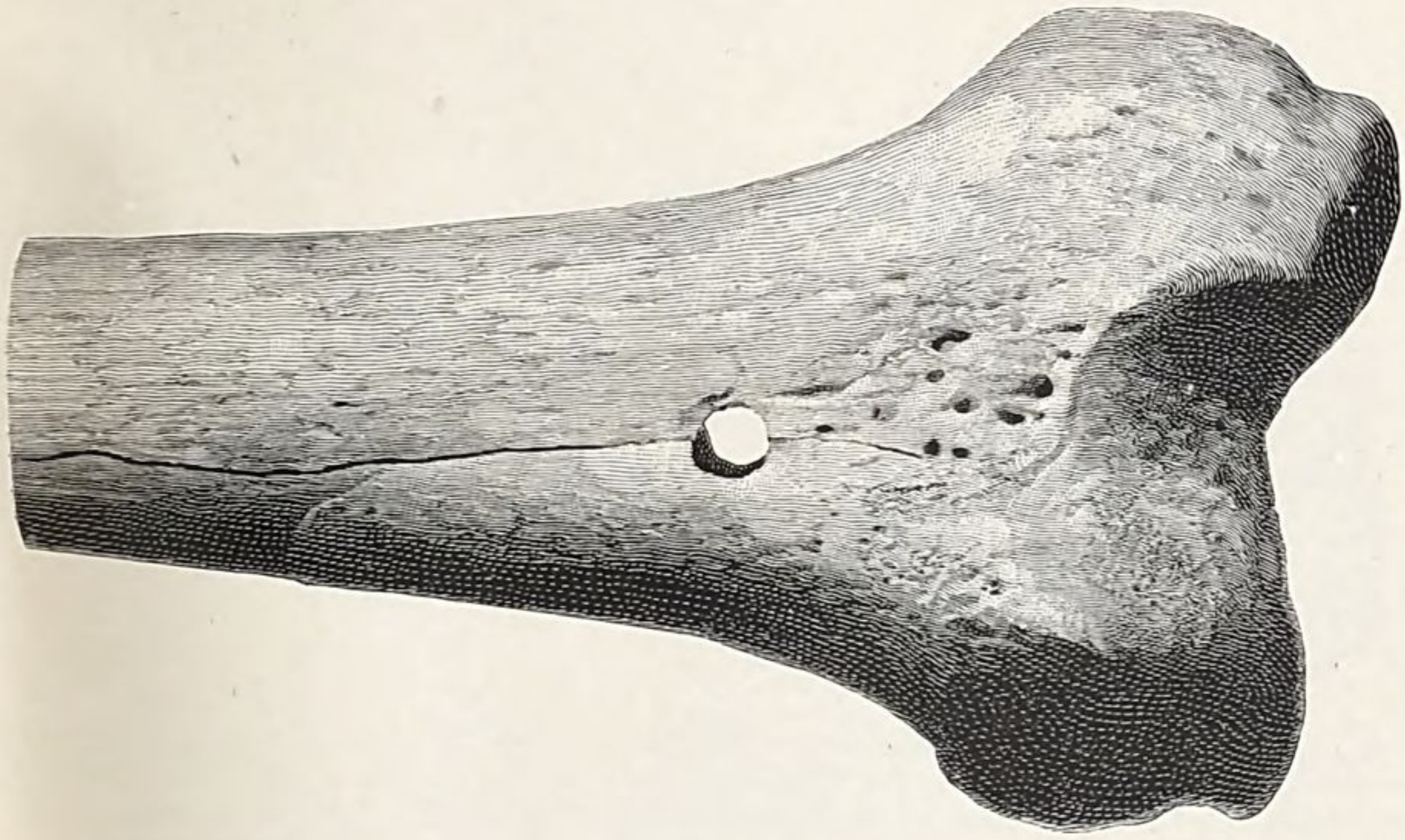


FIG. 1. Gunshot injury of the lower third, right femur, by the .30-caliber German silver jacketed projectile with the velocity common at 1,200 yards. The projectile perforated the anterior face of the bone about its middle, immediately above the upper margin of the articular surface, making a clean-cut perforation.

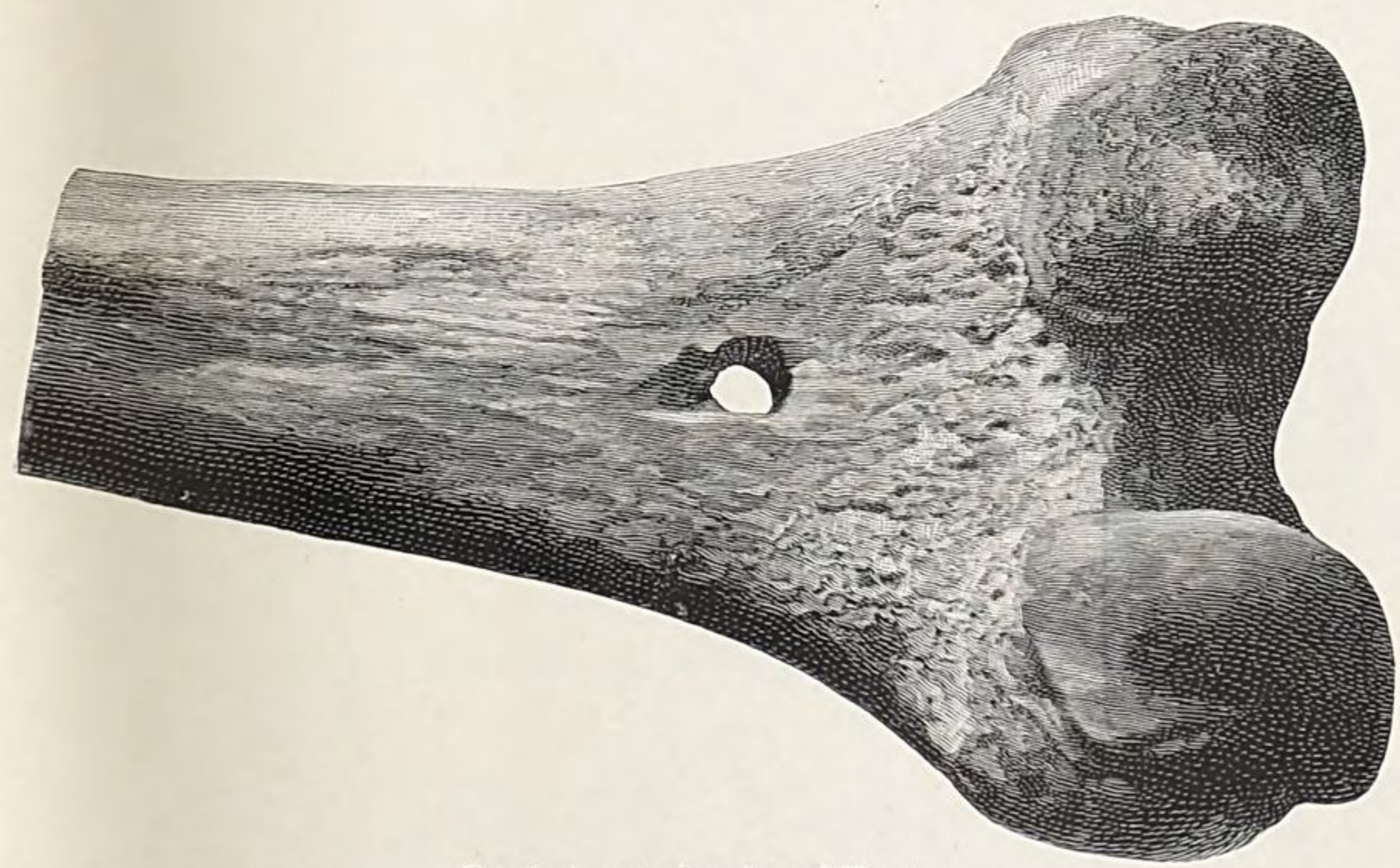


FIG. 2. A posterior view of Fig. 1.

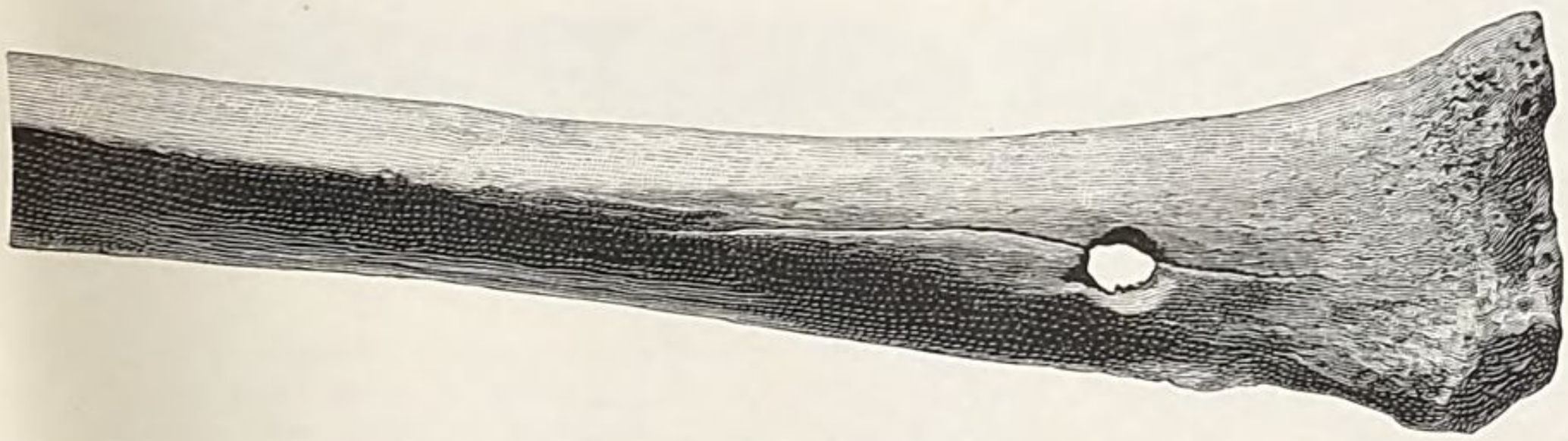


FIG. 1. Gunshot injury, right tibia, near the ankle, by the .30-caliber German silver jacketed projectile with the velocity common at 1,200 yards. The bullet perforated the tibia on the anterior aspect in the middle line 2.17 inches above the ankle joint. The orifice of entrance has a punched-out appearance equal in diameter to that of the projectile.

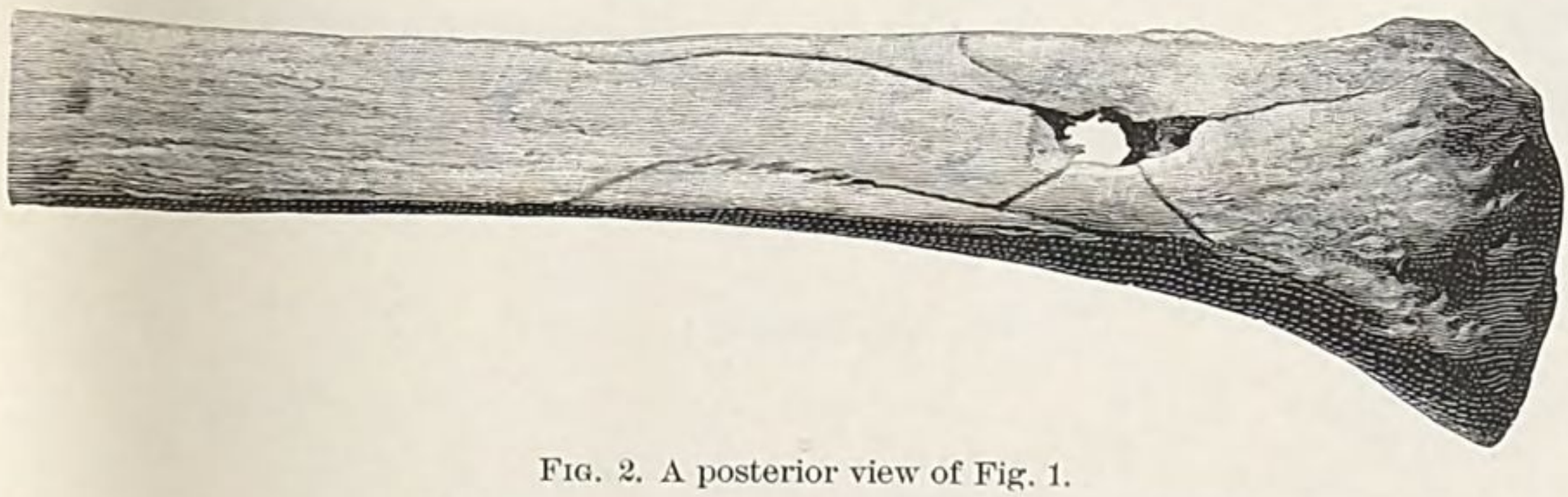


FIG. 2. A posterior view of Fig. 1.

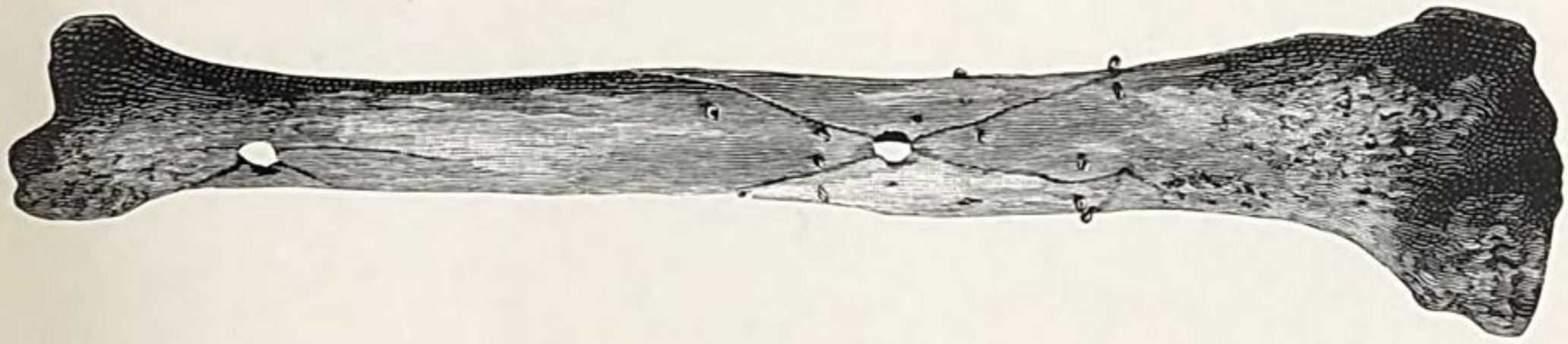


FIG. 1. The specimen shows two perforations of the right tibia by the .30-caliber German silver jacketed projectile with the velocity usually possessed at 1,200 yards. The perforation in the middle of the shaft shows two fissures crossing each other in the form of an X. There is a complete fracture. The lower perforation is attended with less fissuring. There is no solution of continuity.

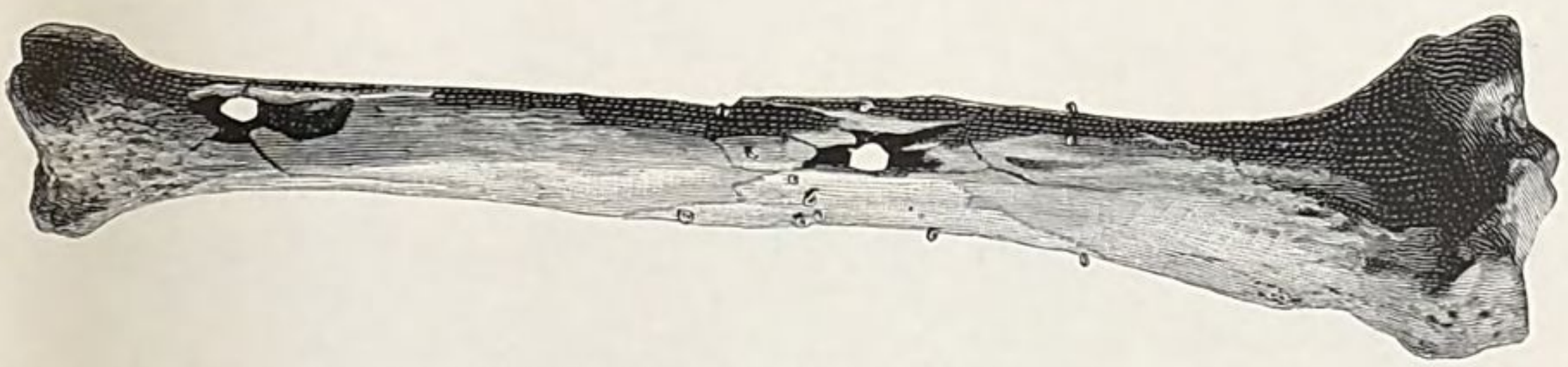


FIG. 2. A posterior view of Fig. 1.

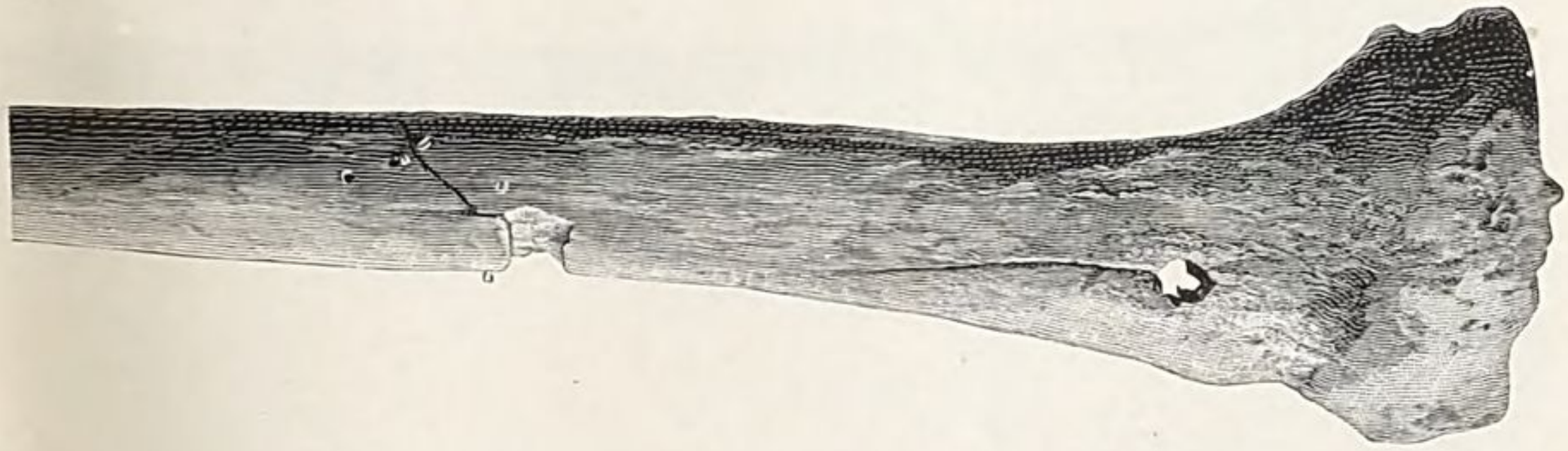


FIG. 1. This specimen shows a complete perforation in the upper part of the shaft of the left tibia by the .30-caliber German silver jacketed projectile with the velocity common at 1,200 yards. There is also an injury in the middle of the shaft by a .30-caliber projectile at the same range. The bullet struck the crest of the tibia, passing wholly in front of the medullary canal, guttering the crest. There is a complete fracture. There is no record of the injury near the ankle.

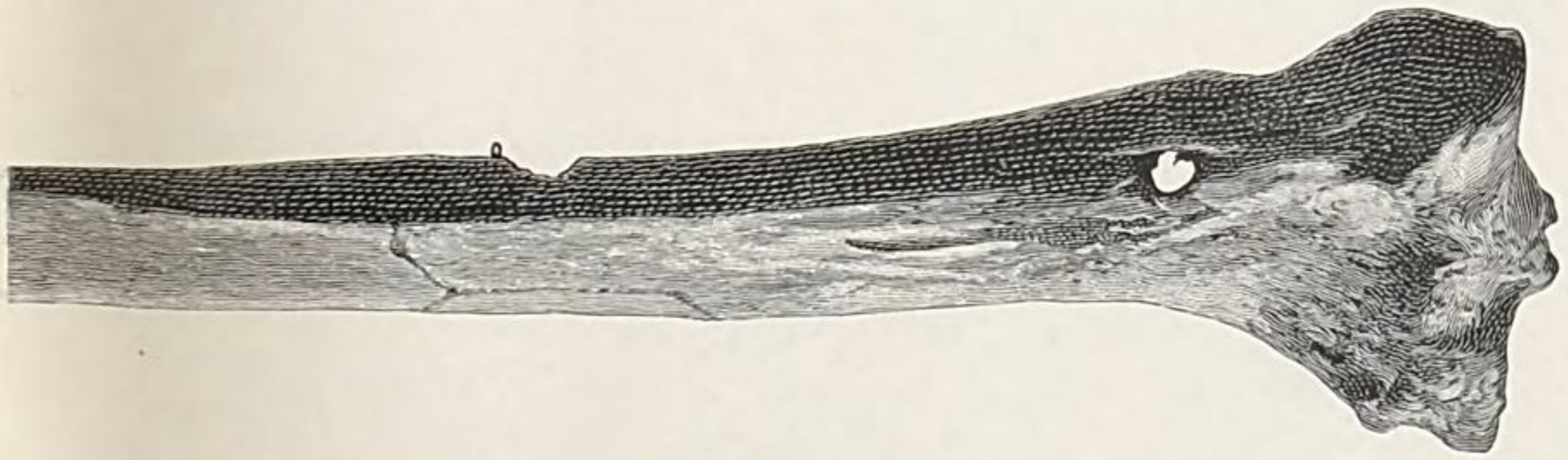


FIG. 2. A posterior view of Fig. 1.

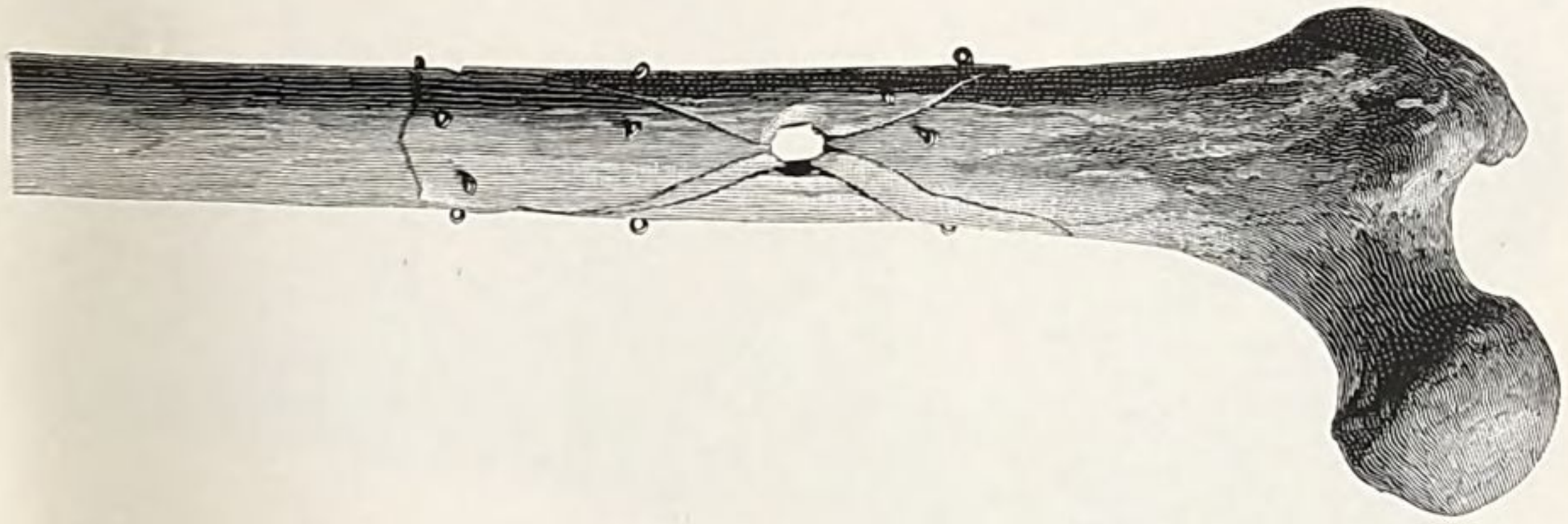


FIG. 1. Gunshot injury of the right femur at junction of middle and upper thirds by the .30-caliber German silver jacketed projectile with the velocity common at 2,000 yards. There is a well-marked perforation with extensive fissuring.

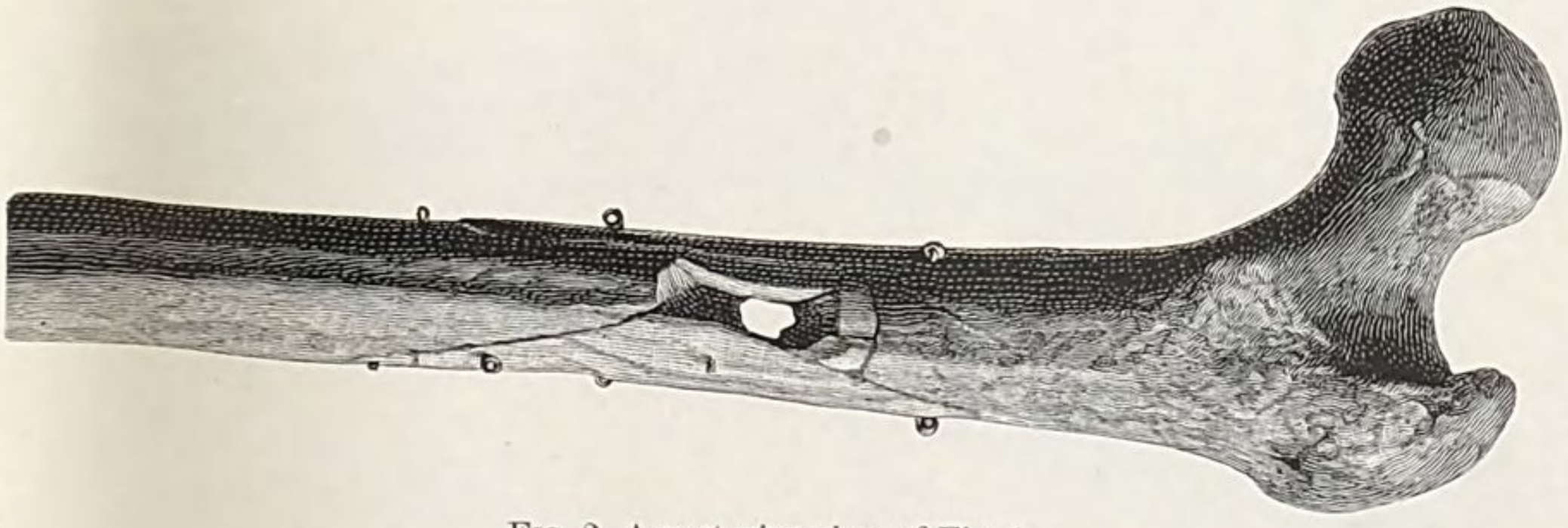


FIG. 2. A posterior view of Fig. 1.

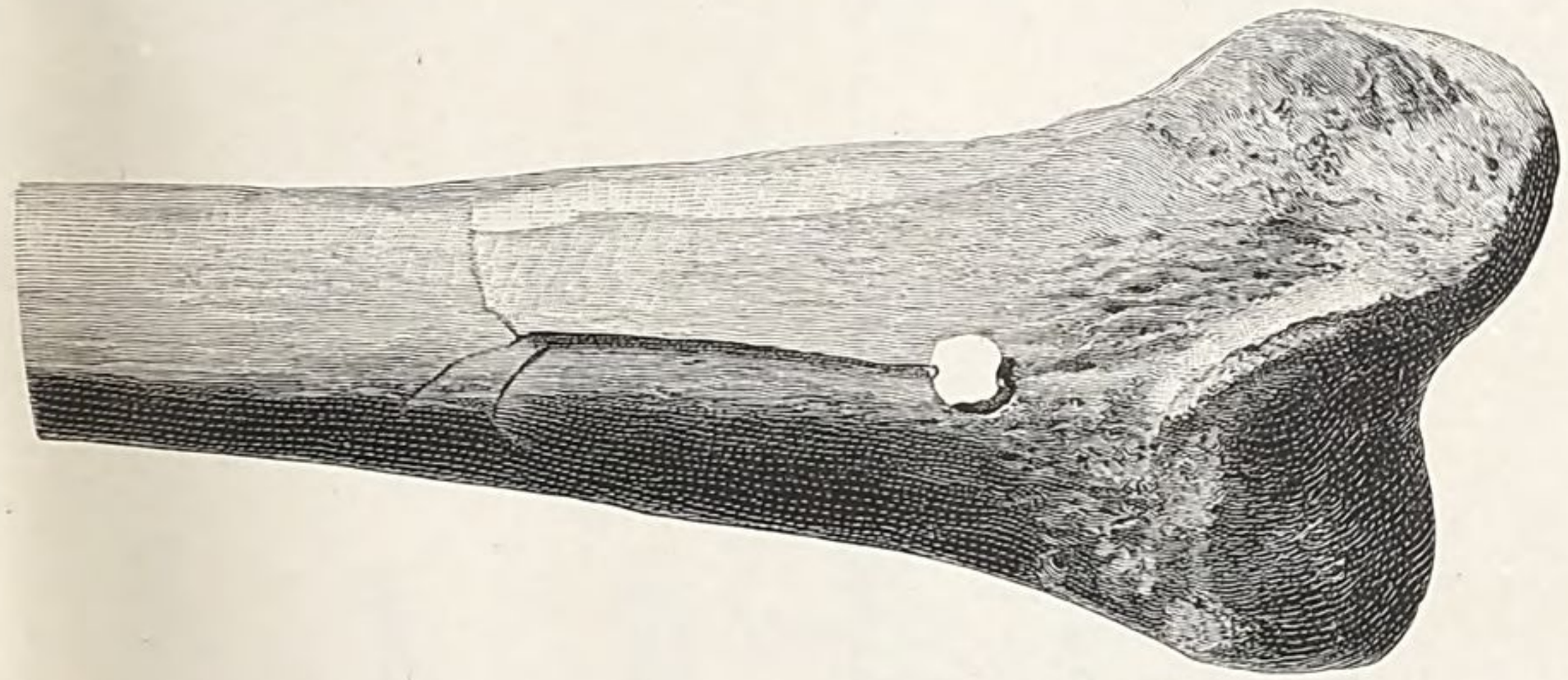


FIG. 1. Gunshot injury, lower third, right femur, by the .30-caliber German silver jacketed projectile possessed with the velocity usual at 2,000 yards. The projectile entered the bone 0.79 inch above the articular surface, making a perforation with long fissures.

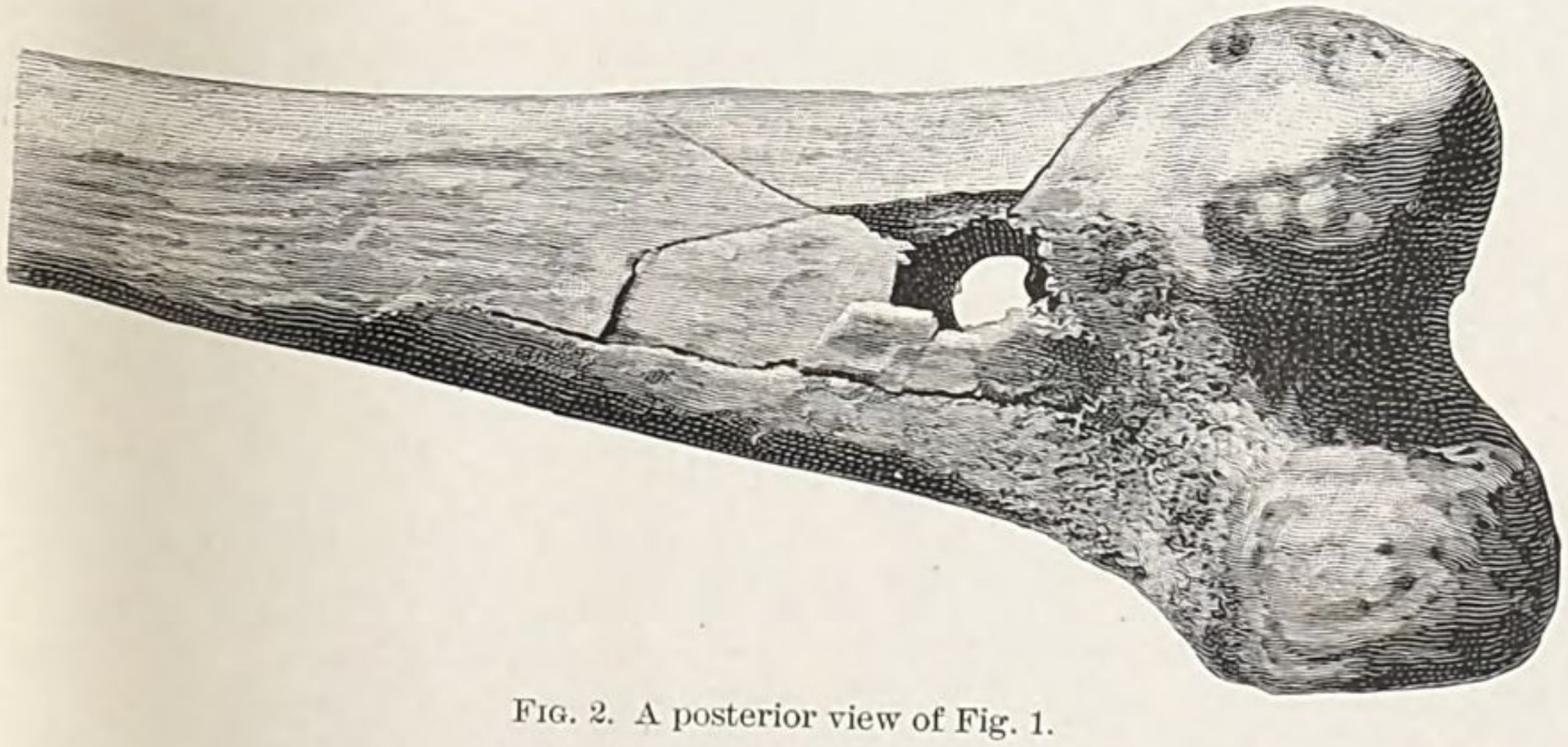


FIG. 2. A posterior view of Fig. 1.

4 50 45 39 23 15

Specimens showing the more common deformations of the .30-caliber German silver jacketed projectile:

No. 4. This is a normal .30-caliber German silver jacketed projectile which was never fired.

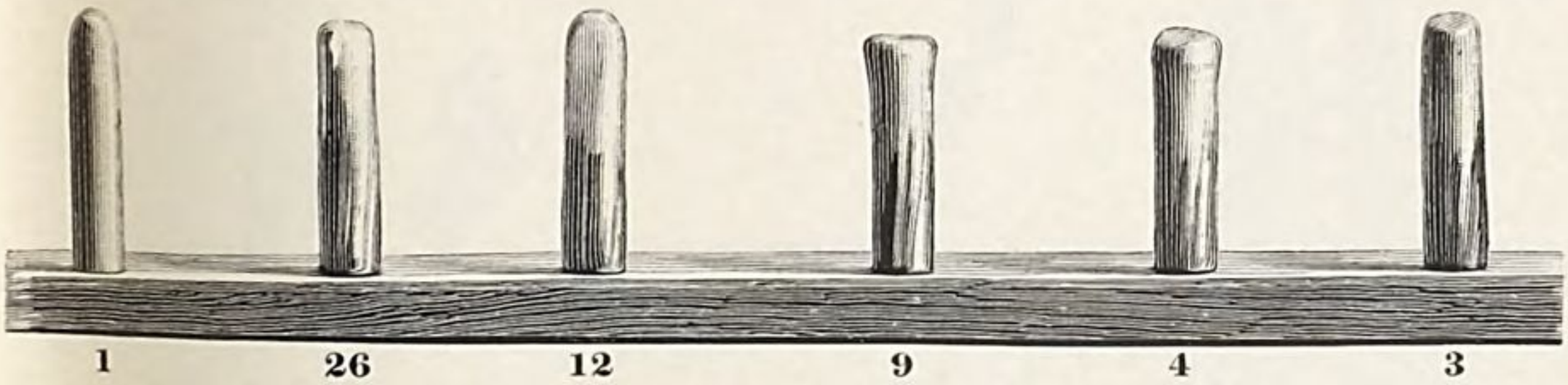
No. 50. A .30-caliber German silver jacketed projectile after inflicting a comminuted fracture of the tibia and fibula with the velocity common at 150 yards.

No. 45. A .30-caliber German silver jacketed projectile which caused perforation of the astragalus with the velocity usual at 350 yards.

No. 39. A .30-caliber German silver mantle projectile which inflicted a perforation of the surgical neck of the humerus with little comminution with the velocity common at 350 yards.

No. 23. A .30-caliber German silver jacketed projectile after inflicting a perforation, with slight fissuring of the middle of the shaft of the tibia, when propelled with the velocity usual at 1,200 yards.

No. 15. A .30-caliber German silver jacketed projectile after inflicting a complete fracture, with extensive fissures of the middle of the shaft of the femur, while possessed with the velocity usual at 1,500 yards.



Specimens showing the more common deformations of the .30-caliber German silver jacketed projectile:

No. 1. A normal .30-caliber German silver jacketed projectile which was never fired.

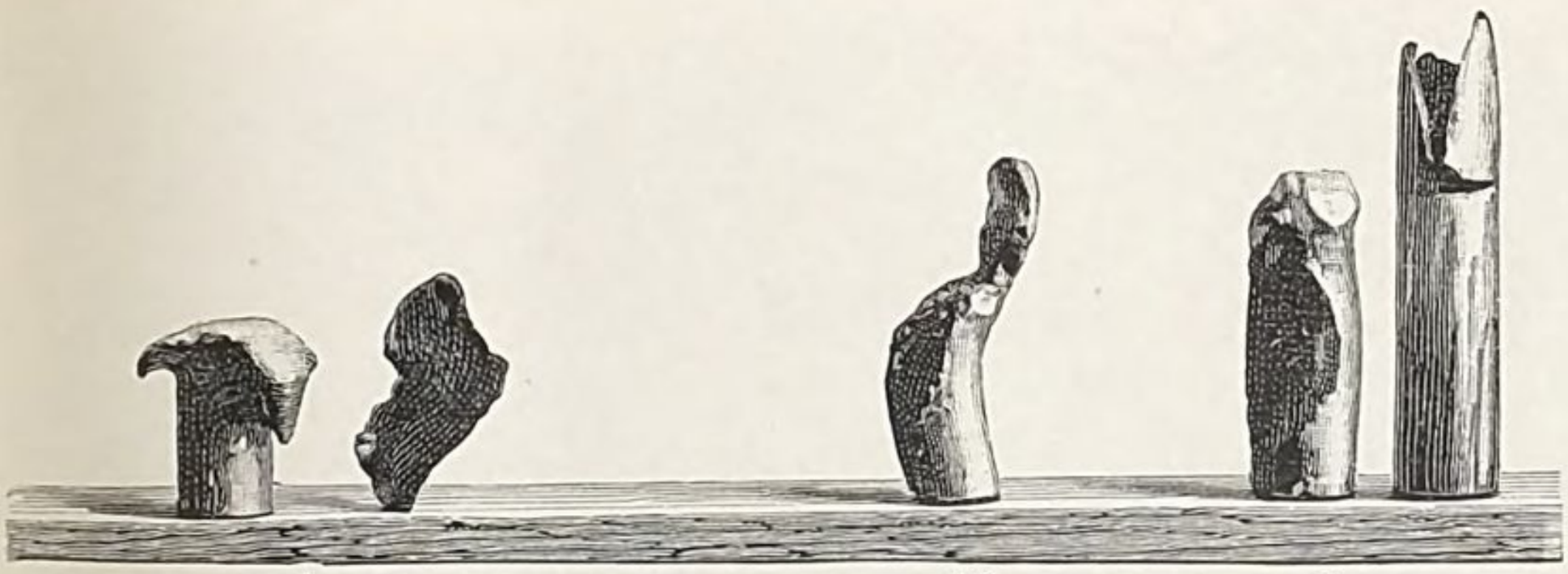
No. 26. A .30-caliber German silver jacketed projectile showing the deformation sustained upon fracturing the middle of the shaft of the tibia when possessed with the velocity usual at 1,200 yards.

No. 12. A .30-caliber German silver jacketed projectile showing the deformation sustained upon causing a fracture, with slight comminution of the lower half of the humerus, while possessed with the velocity common at 1,500 yards.

No. 9. A .30-caliber German silver jacketed projectile showing deformation after fracture of the middle half of the femur when possessed with the velocity common at 1,500 yards.

No. 4. A .30-caliber German silver jacketed projectile showing the deformation upon colliding with the upper third of the femur while propelled with the velocity common at 2,000 yards.

No. 3. A .30-caliber German silver jacketed projectile showing the deformation sustained upon fracturing the middle third of the tibia when propelled by the velocity usual at 2,000 yards.



4 10 1

Specimens showing unusual deformations of the .30-caliber German silver jacketed projectiles :

No. 4. A .30-caliber German silver jacketed projectile showing separation of the nucleus from the envelope ; the nucleus is badly mushroomed, and only a fragment of the envelope was recovered. The projectile was fired into the arm at 17 yards with the full charge of powder. The humerus was pulverized 3 inches in extent, and the soft parts showed extensive explosive effects.

No. 10. A .30-caliber German silver jacketed projectile showing deformation after causing extensive comminution of the femur when propelled with the velocity common at 500 yards. The nucleus alone was recovered.

No. 1. A .30-caliber German silver jacketed projectile showing the deformation sustained after perforating the lower shaft of the femur when possessed with the velocity usual at 2,000 yards. The nucleus has escaped from the envelope through a rent in the conical end. The concavity in the nucleus was probably sustained by colliding with another projectile in the sawdust.

Appendix 19, 1893.

(1368B–93.)

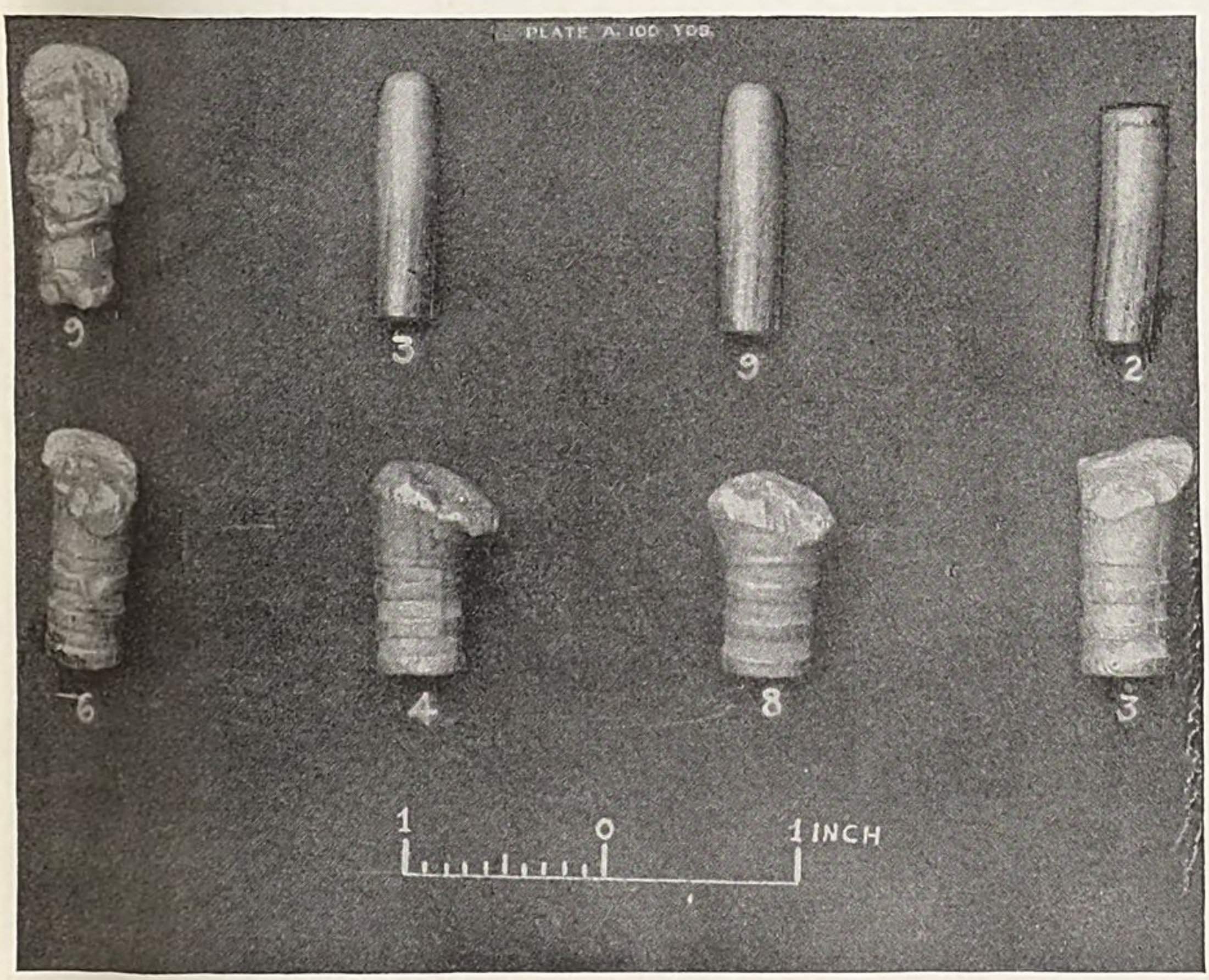


PLATE A. 100 YDS.
9
3
9
2
6
4
8
3
1
0
1 INCH

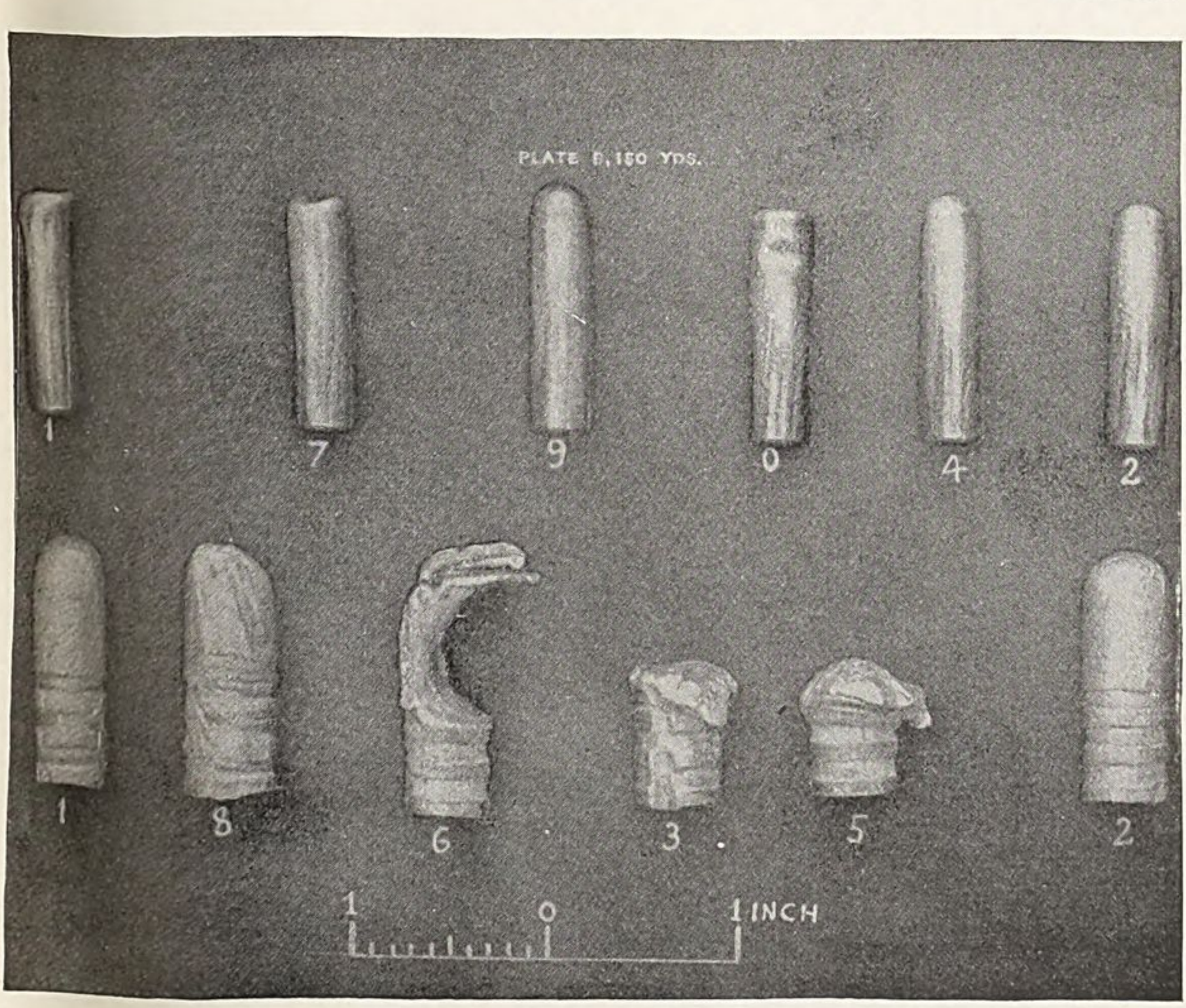
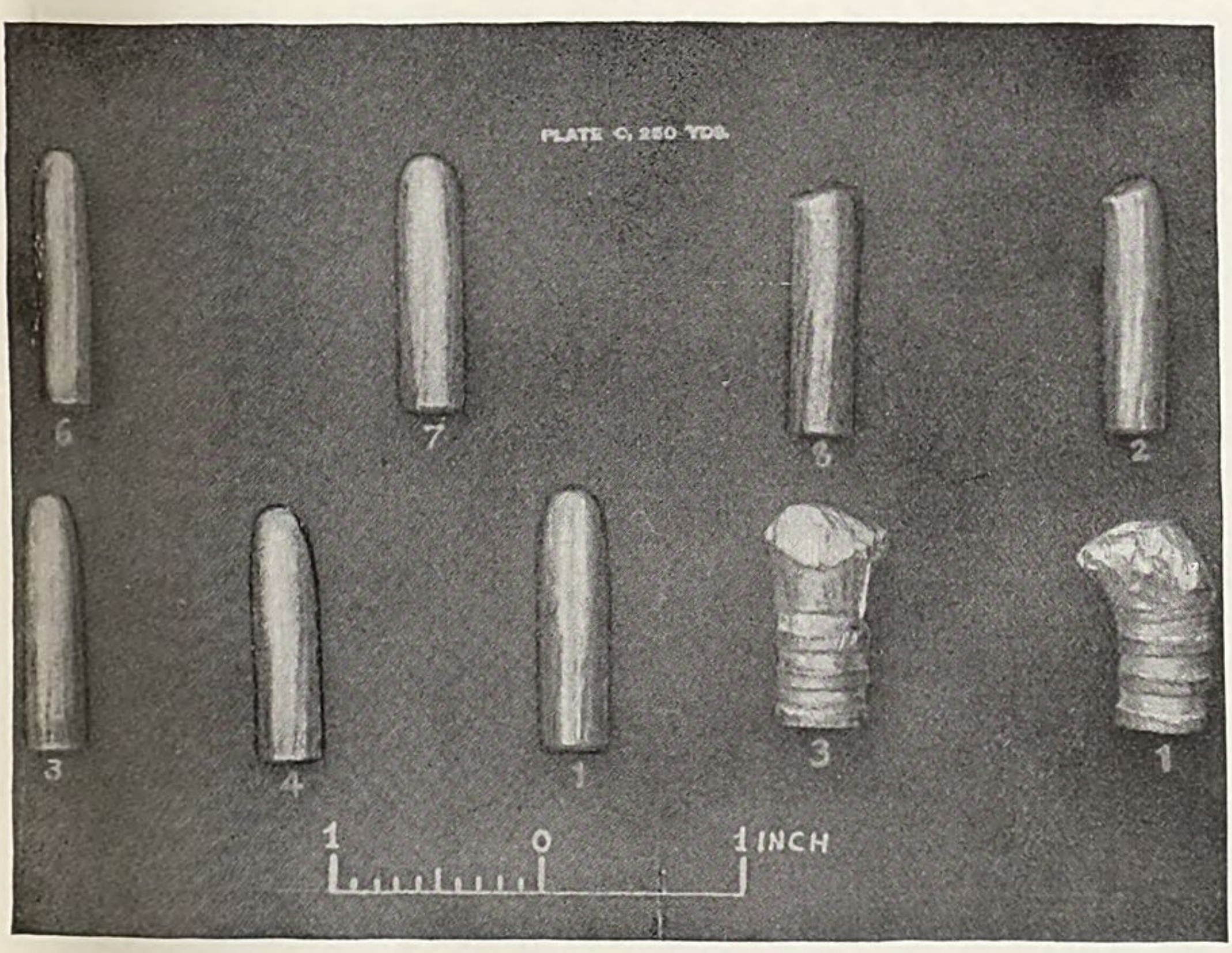


PLATE B, 150 YDS.
1
7
9
0
4
2
1
8
6
3
5
2
1
0
1 INCH

PLATE C.



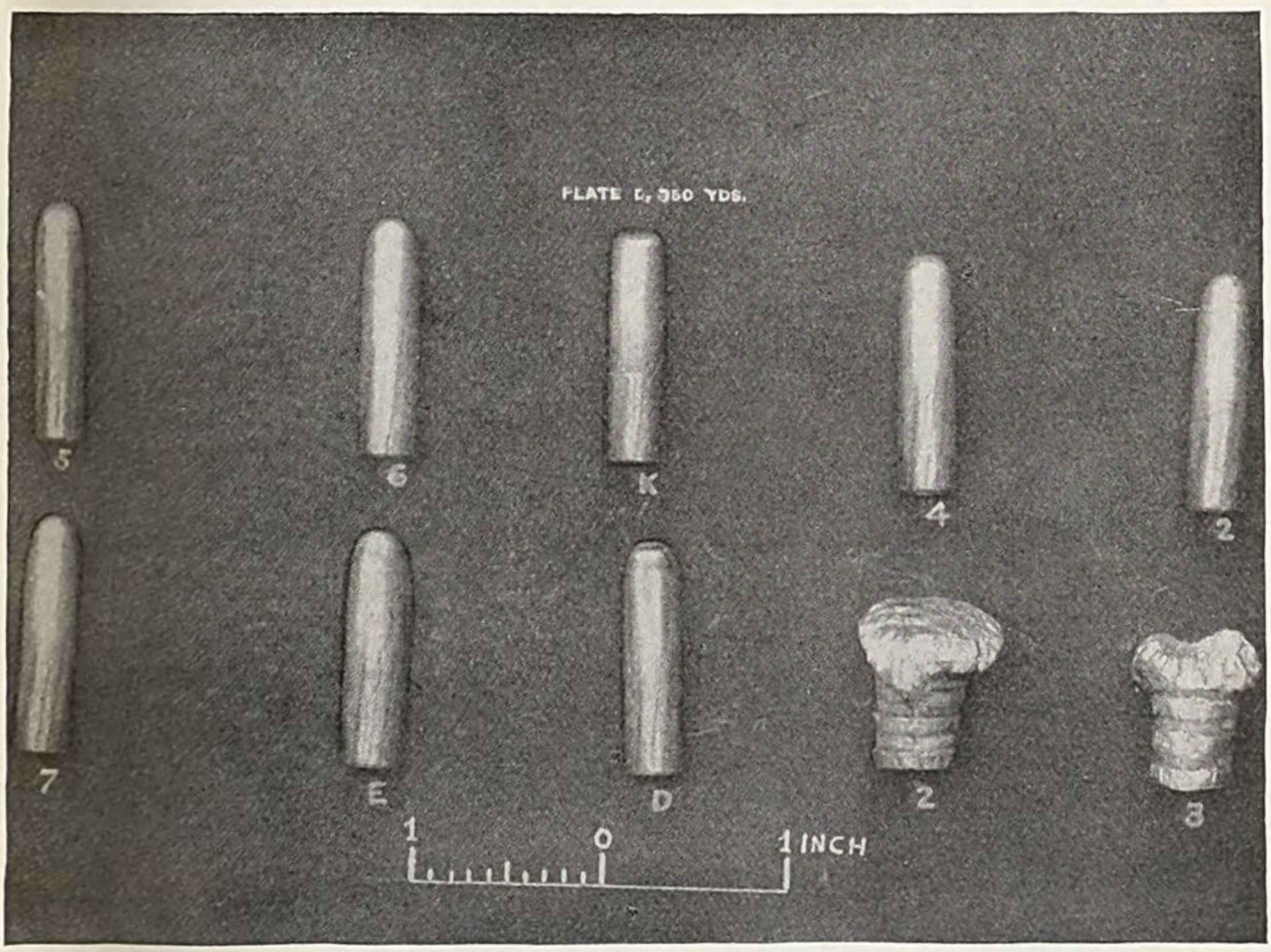


PLATE D, 950 YDS.
5
6
K
4
2
7
E
D
2
3
1
0
1 INCH

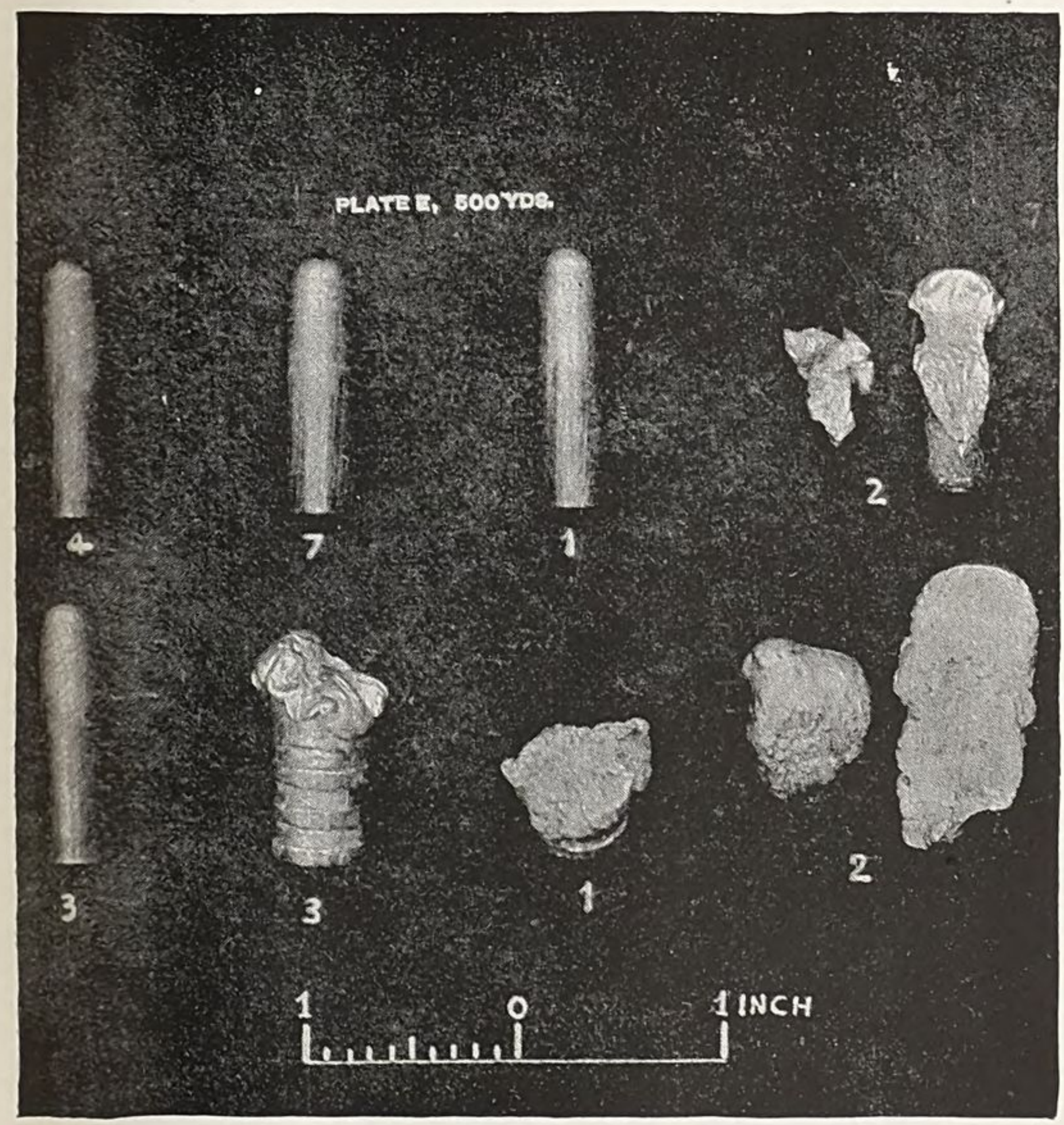


PLATE E, 500 YDS.
4
7
1
2
3
3
1
2
1 0 1 INCH

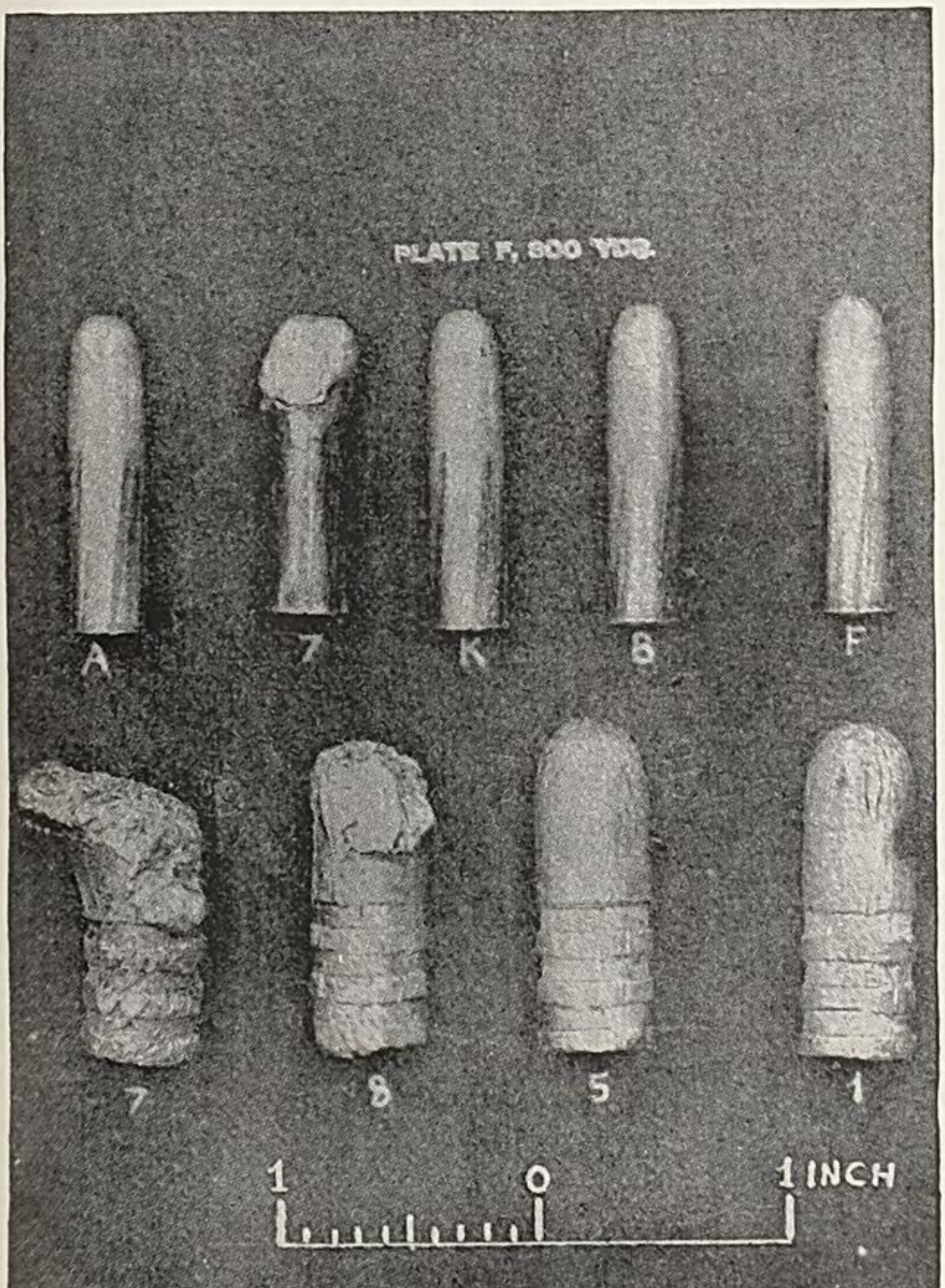


PLATE F, 800 VOLTS
A
7
K
8
F
7
8
5
1
1
0
1 INCH

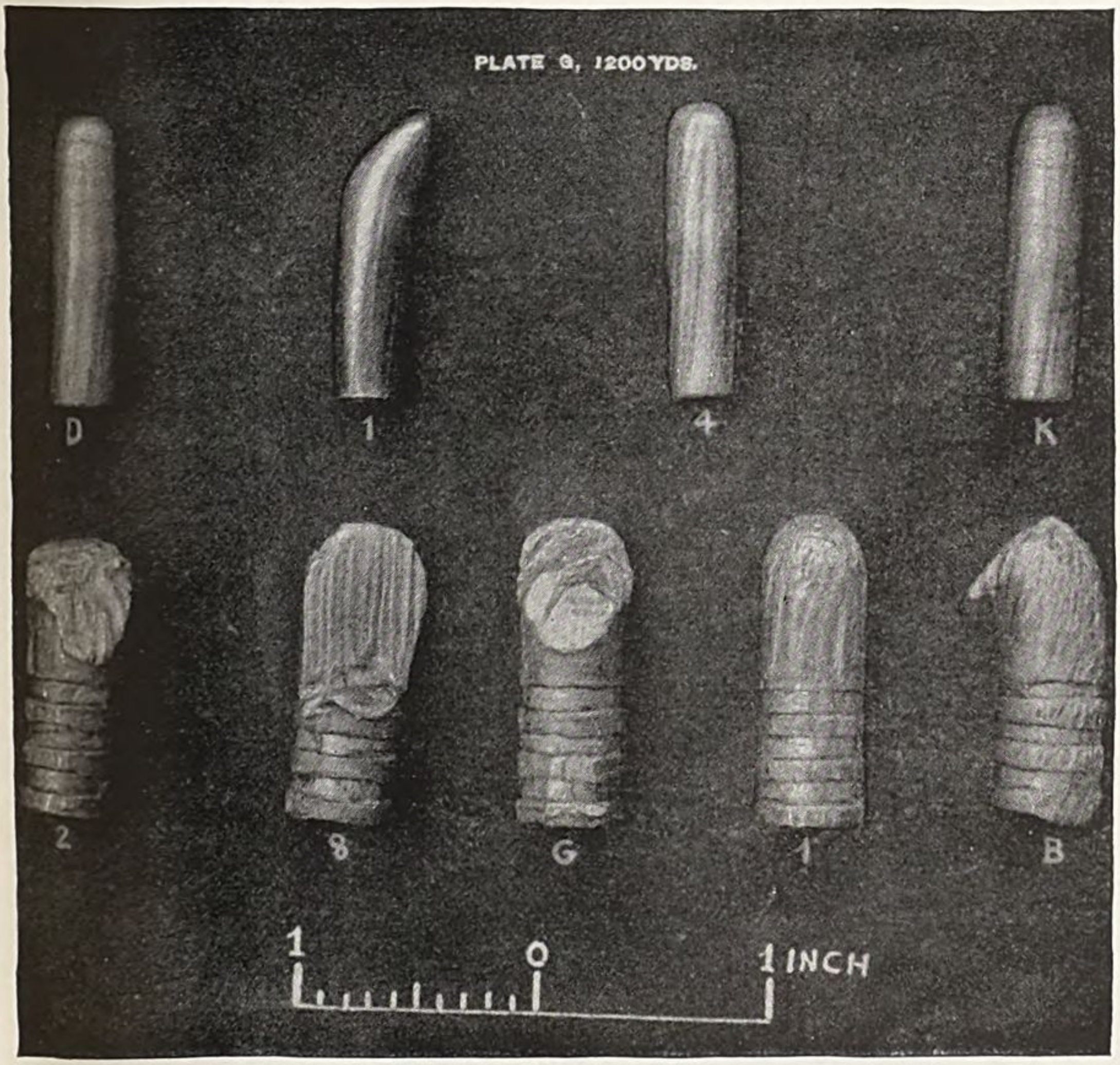
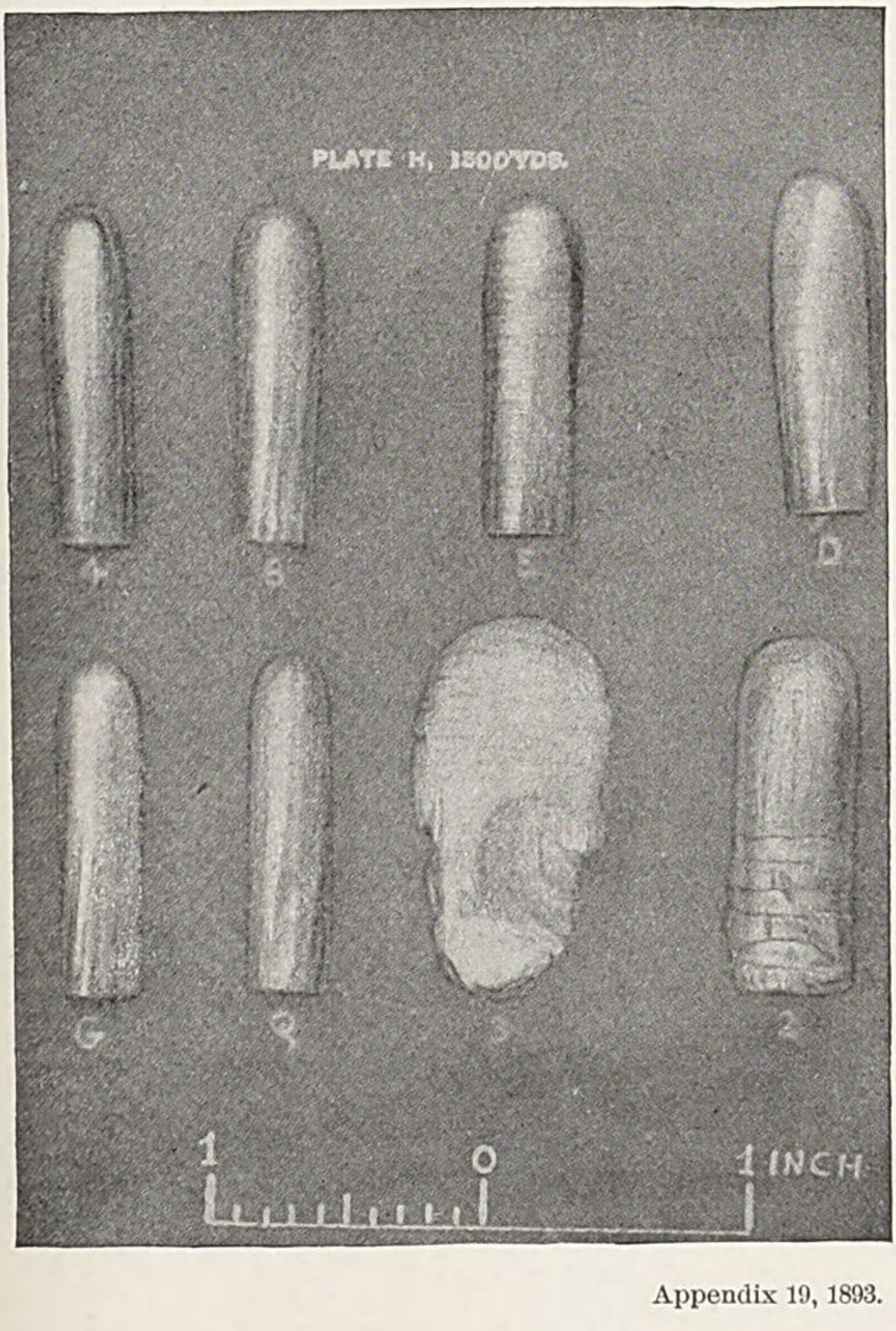


PLATE G, 1200 YDS.
D
1
4
K
2
8
G
1
B
1
0
1 INCH

PLATE H.



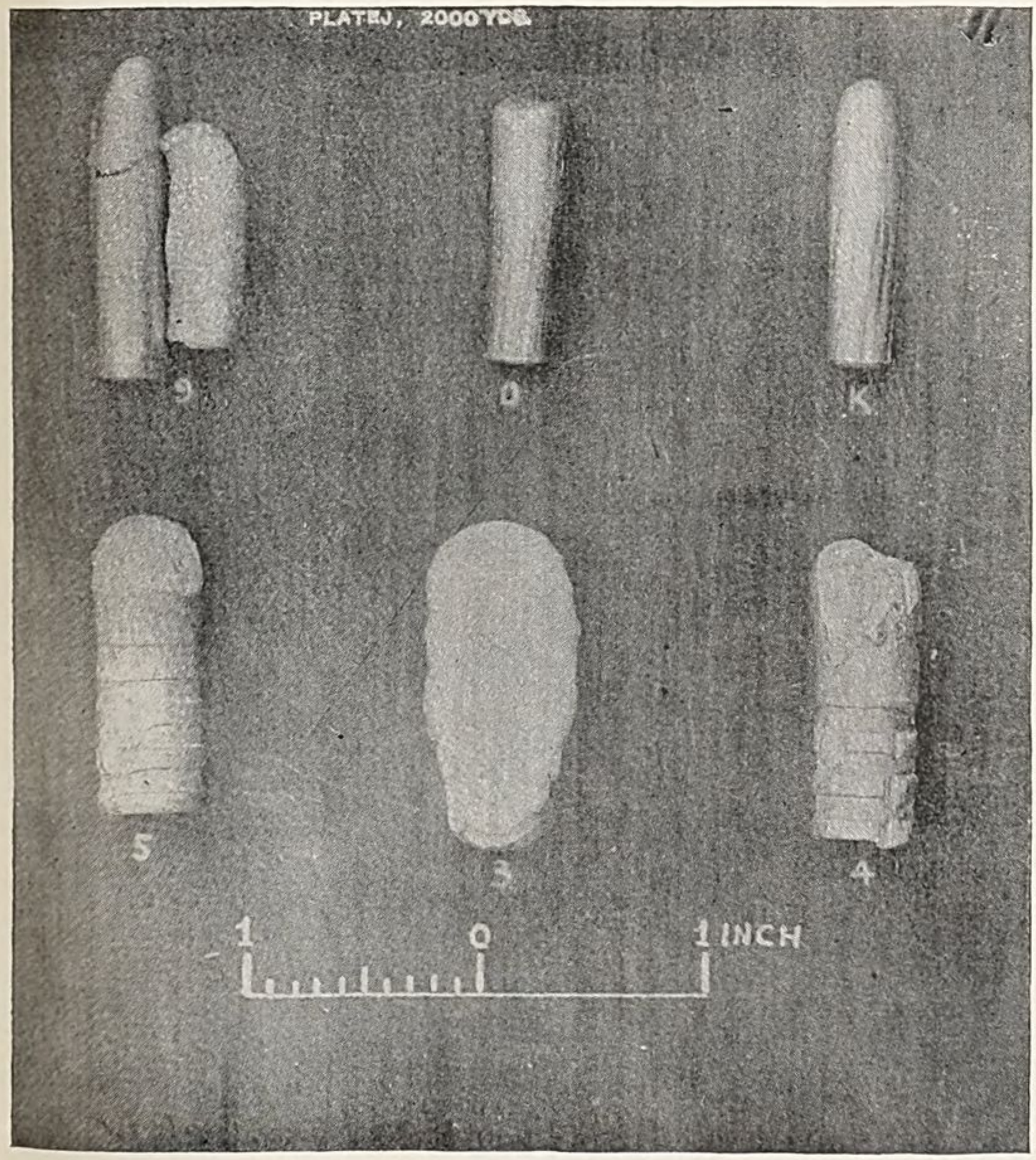


PLATE J, 2000 YDS.
9
0
K
5
3
4
1
0
1 INCH

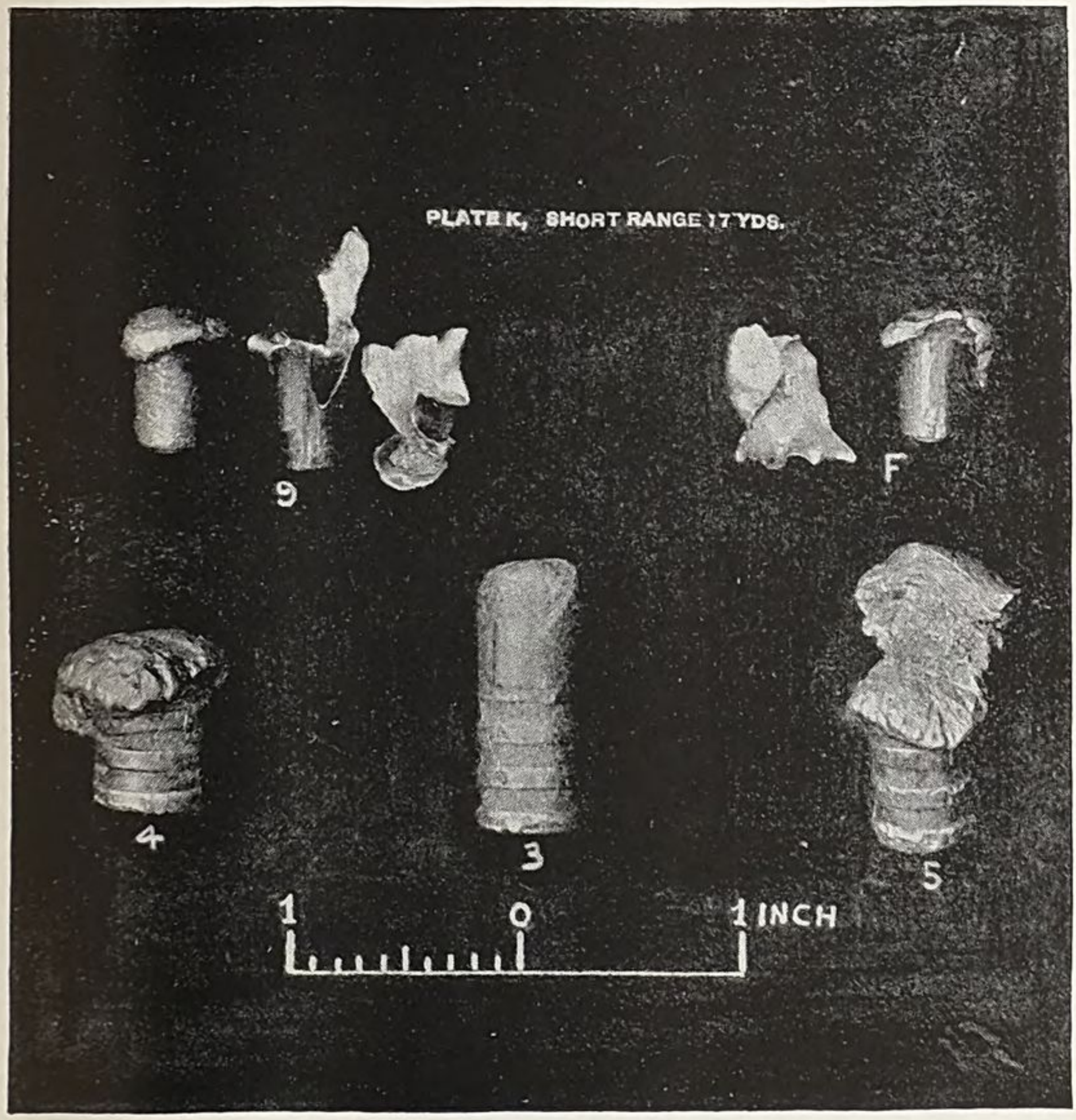


PLATE K, SHORT RANGE 17 YDS.
9
F
4
3
5
1
0
1 INCH

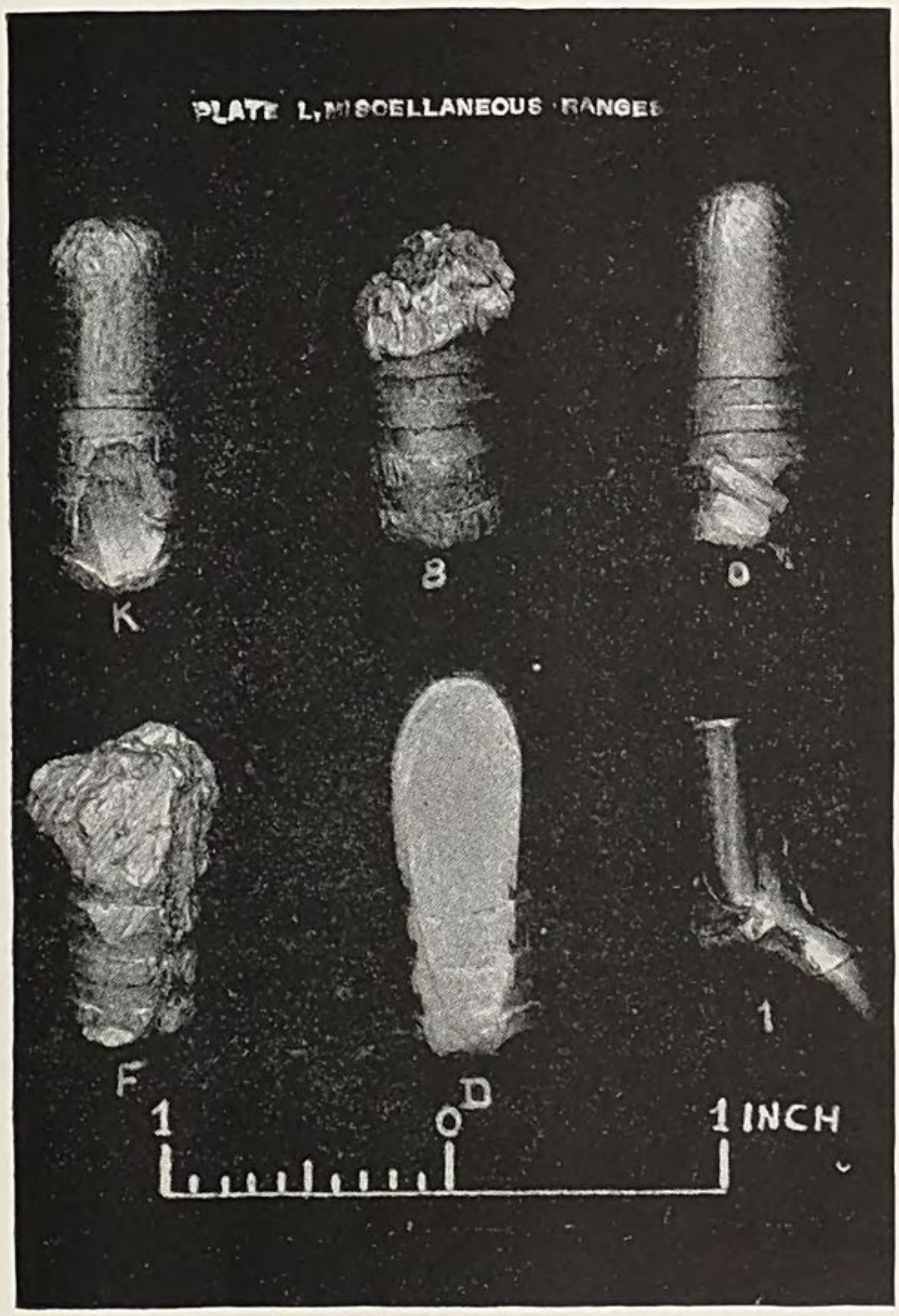
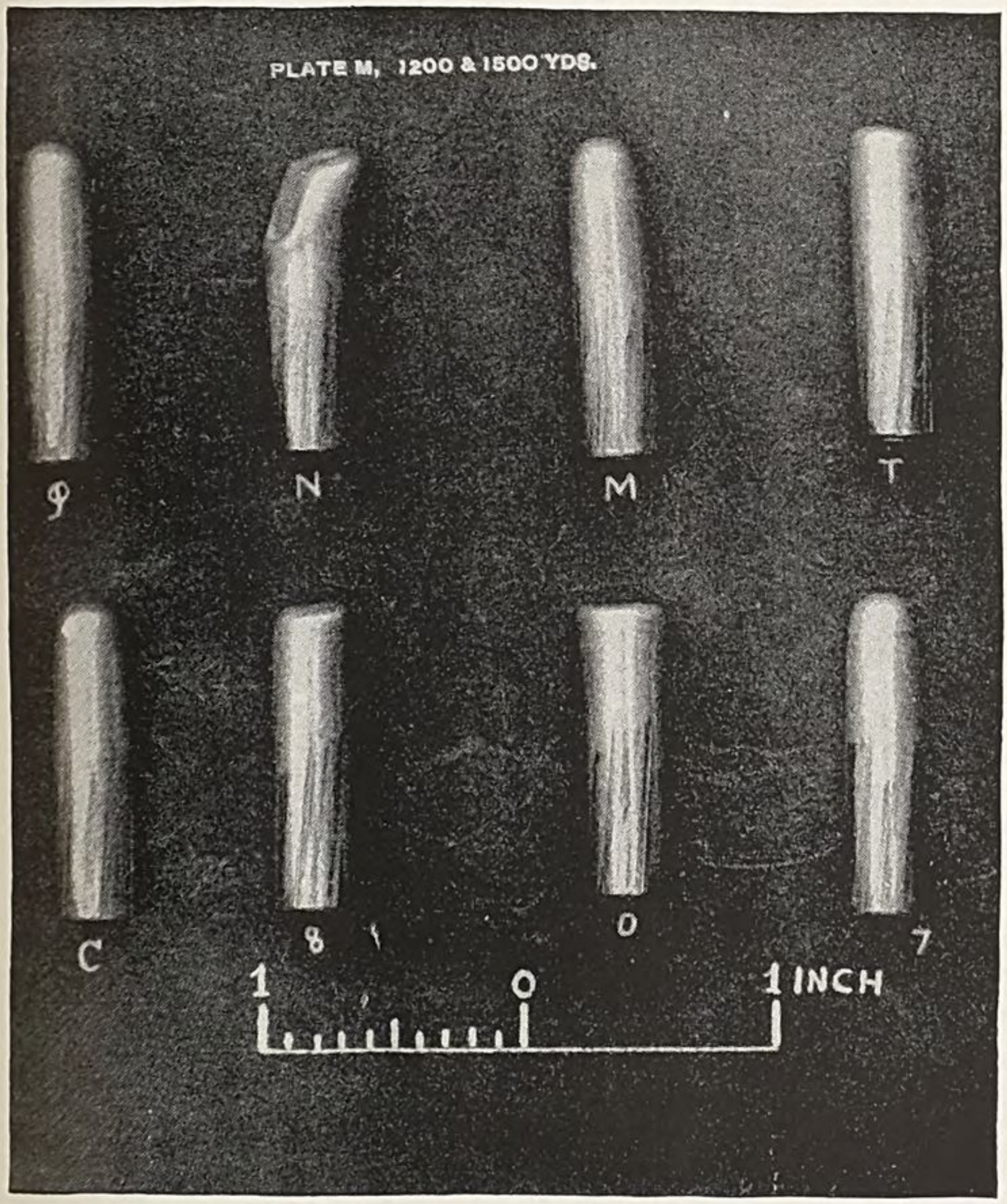


PLATE L, MISCELLANEOUS RANGES
K
8
O
F
D
1
1 INCH

PLATE M.



APPENDIX 20.

METHODS AND APPLIANCES FOR BALLISTIC WORK AT FRANKFORD ARSENAL, PENNSYLVANIA, BY SECOND LIEUT. R. G. PAXTON, TENTH CAVALRY.

(6 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., July 31, 1893.

SIR: In accordance with your instructions, I have the honor to submit the following report upon the methods and appliances used in the ballistic department at this post with photographs, plans, and description of recent improvements. The proof-house (Pl. I) was built in 1888.

VELOCITY.

The Vignotti and Benton electro-ballistic pendulums are on hand, and may be employed in the determination of initial velocities, but the Boulengé chronograph, having given more satisfactory results, is now used for that purpose. Two of the latter, one having the Bréger modification, are used simultaneously to check instrumental error. Two targets are placed in line with the fixed rest used for velocity firings in the proof-house. Over the first target are stretched fine copper wires so placed that they will be cut by the bullet; through these wires passes the current that connects with the magnet supporting the chronometer of the chronograph. The second target, placed at the end of the gallery, 100 feet from the first, consists of a low steel plate, at the back of which is a light steel spring pressed against a pin so as to make connection for the current that magnetizes the support to the registrar of the chronograph. The impact of the bullet on the plate breaks the circuit by imparting a vibratory motion to the spring.

As the manipulation of the chronograph is well known, further description is unnecessary.

The velocity taken from the, tables is that at 53 feet from the muzzle, and can be reduced to the muzzle velocity by means of Ingalls' formulas.

PRESSURE.

The fixed rest and apparatus for pressure firing is so arranged that velocities and pressures can be taken simultaneously.

For determining the maximum pressure per square inch in the powder chamber the Rodman cutter gauge, and later the small-arms crusher gauge—both shown in Pl. I, Appendix 45, of the Report of the Chief of Ordnance, 1892—were employed. The gauge now used at this arsenal is shown in Pl. II.

Error in the determination of the maximum pressure with the crusher gauge arises mainly from two causes: (1) Want of uniformity in the resisting power of the copper cylinders; (2) dynamic effect of the piston.

The first is reduced to a minimum by selecting homogeneous metal, manufacturing the cylinders with the greatest care, and constructing new tarage tables for each lot made up. These tarage tables are constructed at Watertown, by measuring the change in length of the cylinder for every variation of 1,000 pounds in the pressure per square inch.

The dynamic effect may be reduced in two ways: (1) By reducing the weight of the piston; (2) by reducing its path.

The weight of the piston has been reduced by Lieut. Benét from about 300 grains to about 90 grains, this having been found to be the minimum weight of piston that will answer in the apparatus used.

Experiments conducted by Messrs. Sarrau and Vieille with a similar crusher gauge showed that, with a piston weighing 15 grains, the dynamic effect was very slight; with one weighing 50 grains it was still a negligible quantity; while with the next weight tried (150 grains) this effect was considerable.

The reduction in the path of the piston is effected by giving the copper cylinders an amount of initial compression which will reduce them to a length slightly greater than their length after firing.

The amount of this difference in the length of the cylinders before and after firing must be experimentally determined for each lot of cylinders and for the gauge used. It must in each case be slightly greater than the dynamic effect. Suppose a shot to be fired giving a certain compression—if the same cylinder be again used with the same charge a further reduction in length will result—this reduction (supposing the powder pressures the same) represents the dynamic effect. As equal charges do not always give the same powder pressure, the dynamic effect can be determined only approximately by a number of experiments.

The copper cylinders at present in use are 0.5 inch in length and 0.206 inch in diameter.

The cartridge cases are prepared for taking pressures by cutting out a circular opening just under the piston, and reducing the thickness of metal around the edges of this opening. Before loading, a piece of tinfoil is pasted over the opening to retain the powder and aid in preventing escape of gas.

RANGE FIRING.

A firing window and fixed rests are arranged for firing at 500 yards.

In firing for accuracy with the Springfield single-loading experimental rifle and smokeless powder it was found that the mean radius of the circle of shots was much greater than that obtained with the .45-caliber rifle and black powder. It was thought that this was due to vibration, buckling, or change in the position of the gun rather than to want of uniformity in the charge. To avoid these errors, a heavy barrel was constructed and firmly bolted in position so as to prevent all motion due to recoil. With this barrel the radius of the circle of shots was reduced some 75 per cent, giving a very accurate target.

This barrel is used in experimenting to eliminate many of the variable causes of error in the rifle, and thereby determine more accurately

the effect of variations in the nature and weight of the charge, the form of the bullet, etc.

It is, of course, not intended as a test of the action of the cartridge in the service rifle.

The method of target practice with the appliance used for making a "camera-obscura diagram" of the targets is described by Capt. Prince, in Ordnance Memoranda No. 8; and the modified method of determining the accuracy is described by Capt. Metcalfe, in Ordnance Notes No. 199.

Pursuant to instructions from the Chief of Ordnance, a system of screens has recently been constructed for the purpose of determining the trajectory of the rifle bullet.

The gun rests in the firing window, being slightly above the level of the top of the target and the range somewhat less than 500 yards. A new gun rest was constructed at A, Pl. I. This consists of a solid masonry pier with the upper plate bolted through to the foundation stone, so as to avoid vibration. A line of levels was run from this point to the target and the muzzle of the rifle placed at the exact height of a bull's eye and 500 yards from it. Permanent masonry piers, for the screen frames, were put in at 300 feet intervals, and wooden piers at 100 feet points, the frames being carefully constructed, and arranged so that the screen can be raised and lowered by a cord passing over pulleys.

The line of level and plane of sight are indicated by a bench mark at each screen. Pl. III is a view of the range with the screens in place.

By this means the following trajectories, at 500 yards, have been measured:

PL. IV. Remington-Hepburn rifle, caliber .40. Charge, 68.1 and 65.1 grains Hazard F. G. powder, 331-grain bullet. Muzzle velocity = 1,441 foot-seconds.

V. Springfield experimental rifle, caliber .30. Charge, 37 grains Wetteren smokeless powder, 220-grain bullet, German-silver jacket. Muzzle velocity about 2,000 foot-seconds.

V. Springfield rifle, caliber .45. Charge, 67 grains Du Pont powder, 500-grain bullet. Muzzle velocity = 1,300 foot-seconds.

FUSE TIMING.

For testing the time of burning of fuses the Schultz chronoscope is used. With reference to this, it will be sufficient to refer to certain modifications made by Gen. Flagler in 1889 for the purpose of adapting the instrument to the timing of fuses.

The tuning fork bearing the registering quill was replaced by an arm which is vibrated to half seconds by means of a spring and an electromagnet, the magnetizing current being broken to half seconds by the clock pendulum.

The glass tube carrying the wire, which is connected with the secondary circuit of the Ruhmkorf coil, is the same as before, except that a second tube is placed on the opposite side of the quill, the wire in this tube being attached to the secondary circuit of a second coil, thus using independent circuits for the sparks denoting the beginning and ending of the time of burning, and placing these sparks on opposite sides of the central line.

A circular arm, 10 inches long, graduated to tenths of an inch, was adjusted so as to encircle the cylinder; by means of this the reading can be taken to one one-thousandth of a second.

The clockwork was altered so as to reduce the horizontal speed of translation of the cylinder.

FUSE-TIMING APPARATUS.

Three instruments have been used to determine the time of burning of the fuse train.

Those of Wernle and McBride are essentially similar, and consist of a circular base holding the fuse, into the top of which an electric primer has been screwed in place of the cap and igniter of the time train, the wires of the primer being connected with the battery. The fuse is pierced at the graduation desired, say ten seconds. A brass plug or hood revolving about an axis is placed over the ten-second opening, and at ignition is blown back, breaking the primary circuit of the first Ruhmkorf coil and inducing in the secondary circuit the current giving the spark on the chronoscope that registers the beginning of the time of burning. When the train burns to the zero point the powder gas presses down a spring lever and breaks the primary circuit of the second coil, registering as before the end of the time of burning.

The Carr fuse-timing device, which is similar in principle to the above, is shown in plan and section, Pl. XIV.

Very respectfully, your obedient servant,

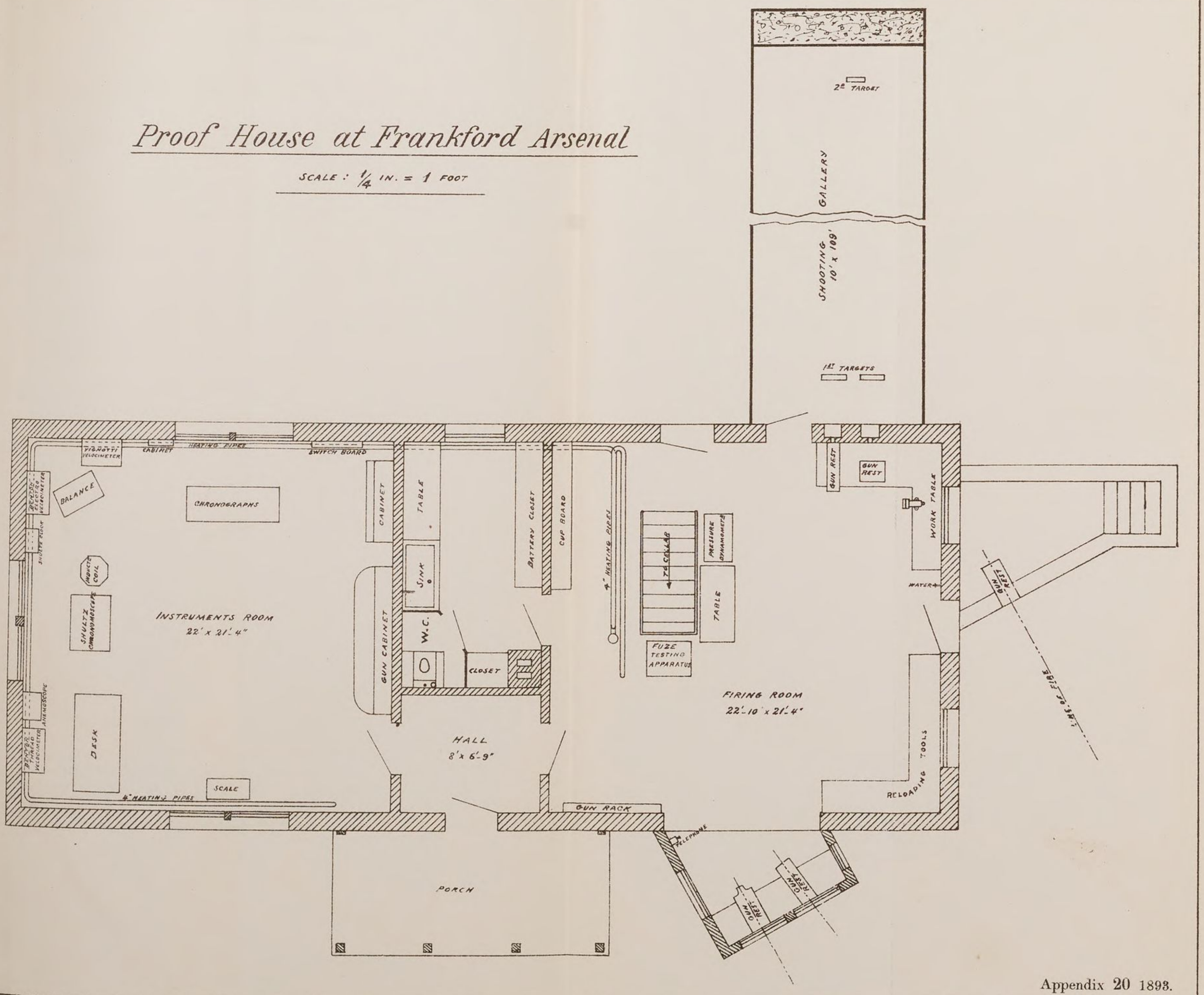
R. G. PAXTON,
Second Lieutenant, Tenth Cavalry.

The COMMANDING OFFICER FRANKFORD ARSENAL.

(4605–'93.)

Proof House at Frankford Arsenal

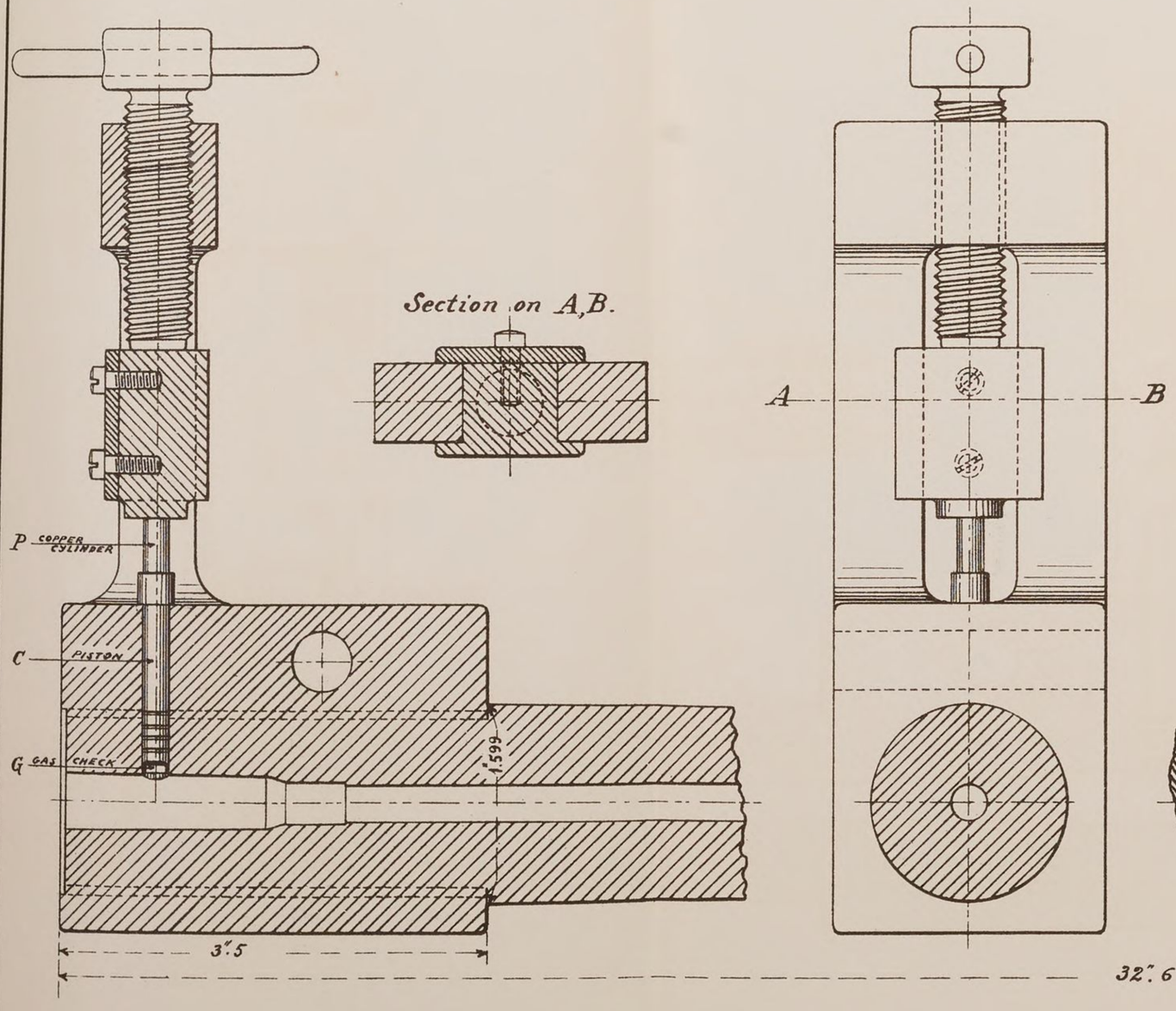
SCALE : 1/4 IN. = 1 FOOT

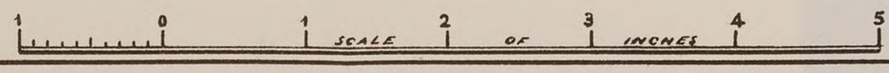


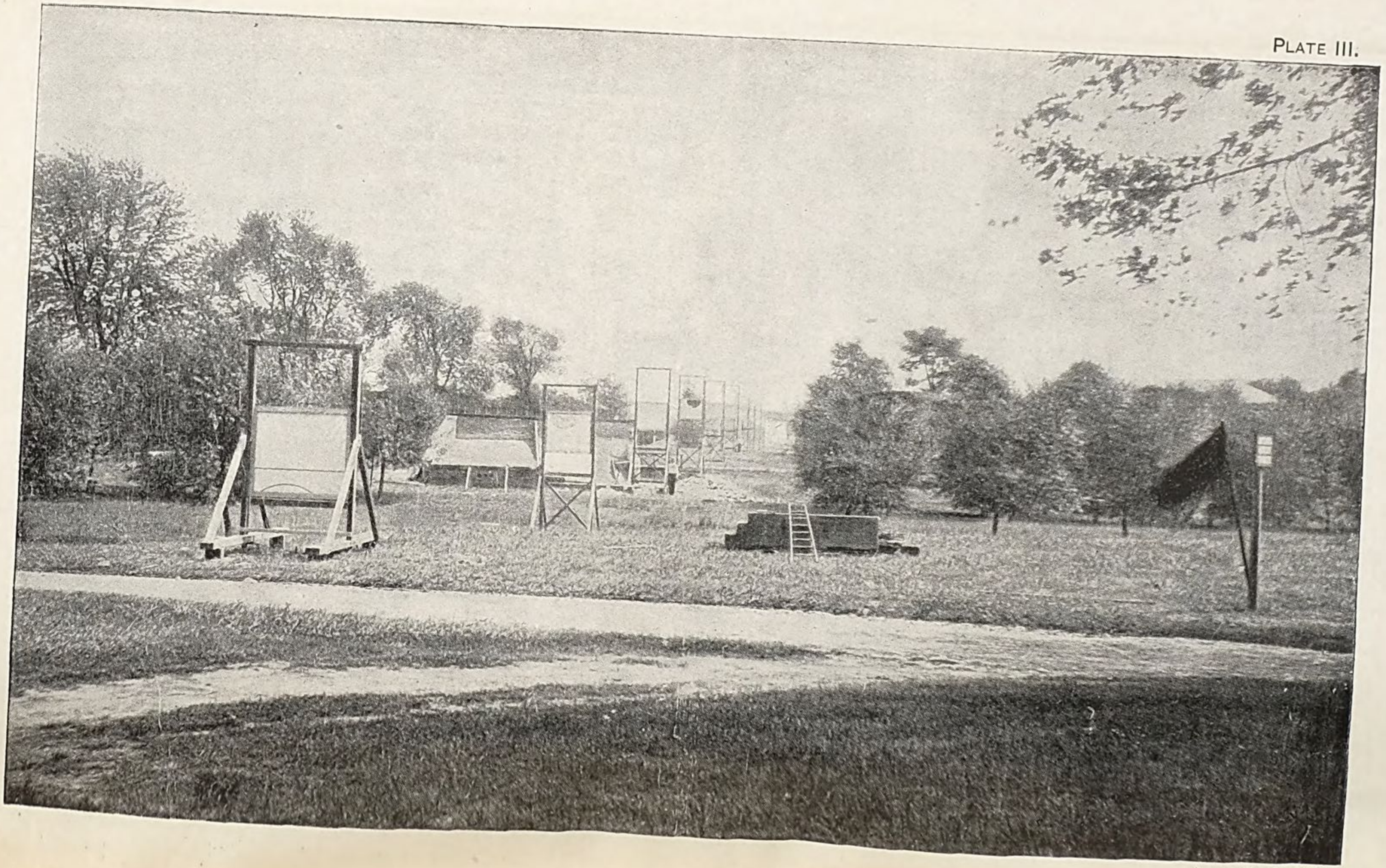
Ord 53 2

Frankford Arsenal
Pressure Gauge & Barrel
for
.30 cal. Cartridge

Total Weight 18 lbs.
3 Grooves and Lands







500 YDS. TRAJECTORIES

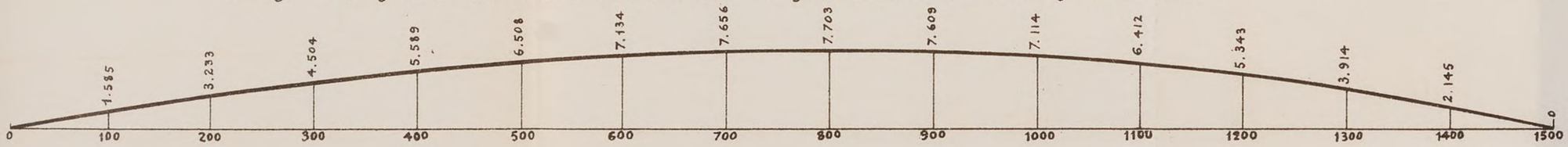
REMINGTON-HEPBURN RIFLE CALIBER .40

DETERMINED EXPERIMENTALLY AT FRANKFORD ARSENAL PA. AUGUST 10TH 1893

Rifle Nº 1

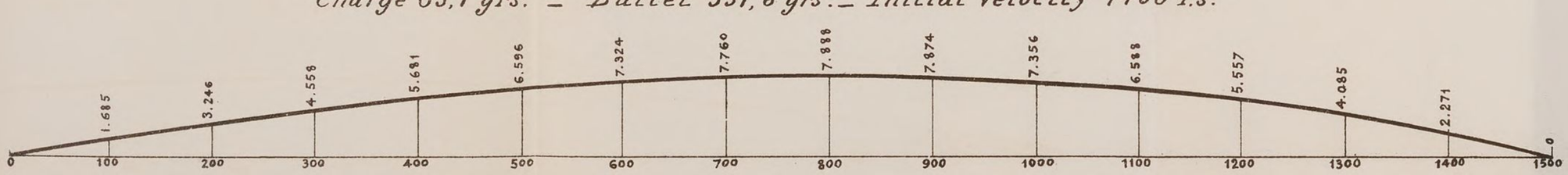
Charge 68,1 grs. – Hazard F.G – Bullet 331 grs. – Initial velocity 1441 f.s.

HORIZONTAL SCALE 100 FT. TO THE INCH
VERTICAL " 10 " " " "

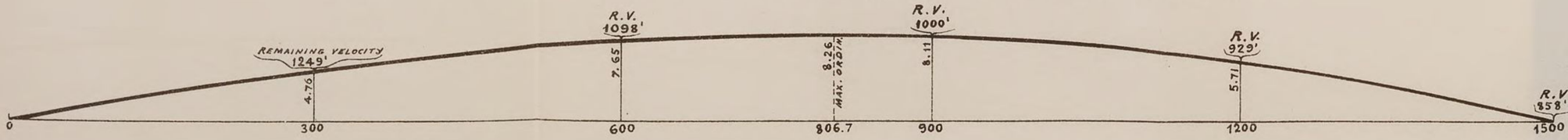


Rifle Nº 2

Charge 65,1 grs. – Bullet 331,6 grs. – Initial velocity 1406 f.s.



Calculated from formulas in Capt. Ingall's "Exterior Ballistics"

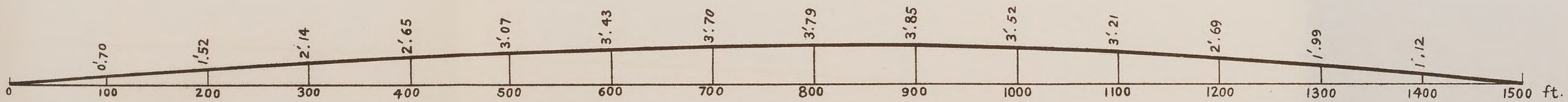


500 Yds. Trajectories determined experimentally at Frankford Arsenal

HORIZONTAL SCALE 100 FT. TO THE INCH
VERTICAL " 10 " " " "

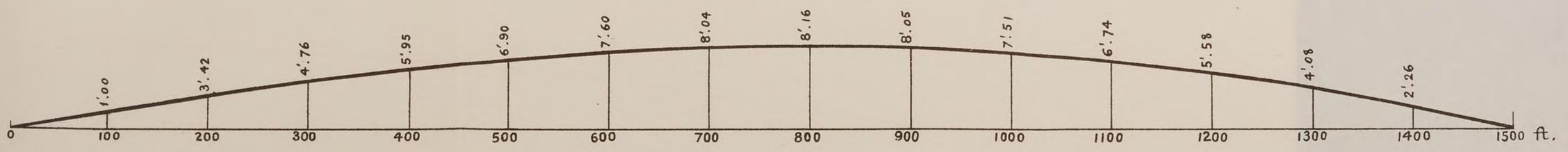
Springfield Experimental Rifle Cal. .30

Charge 37 grs. Wetteren smokeless — 220 grs. Bullet — Initial Velocity over 2000 f.s.



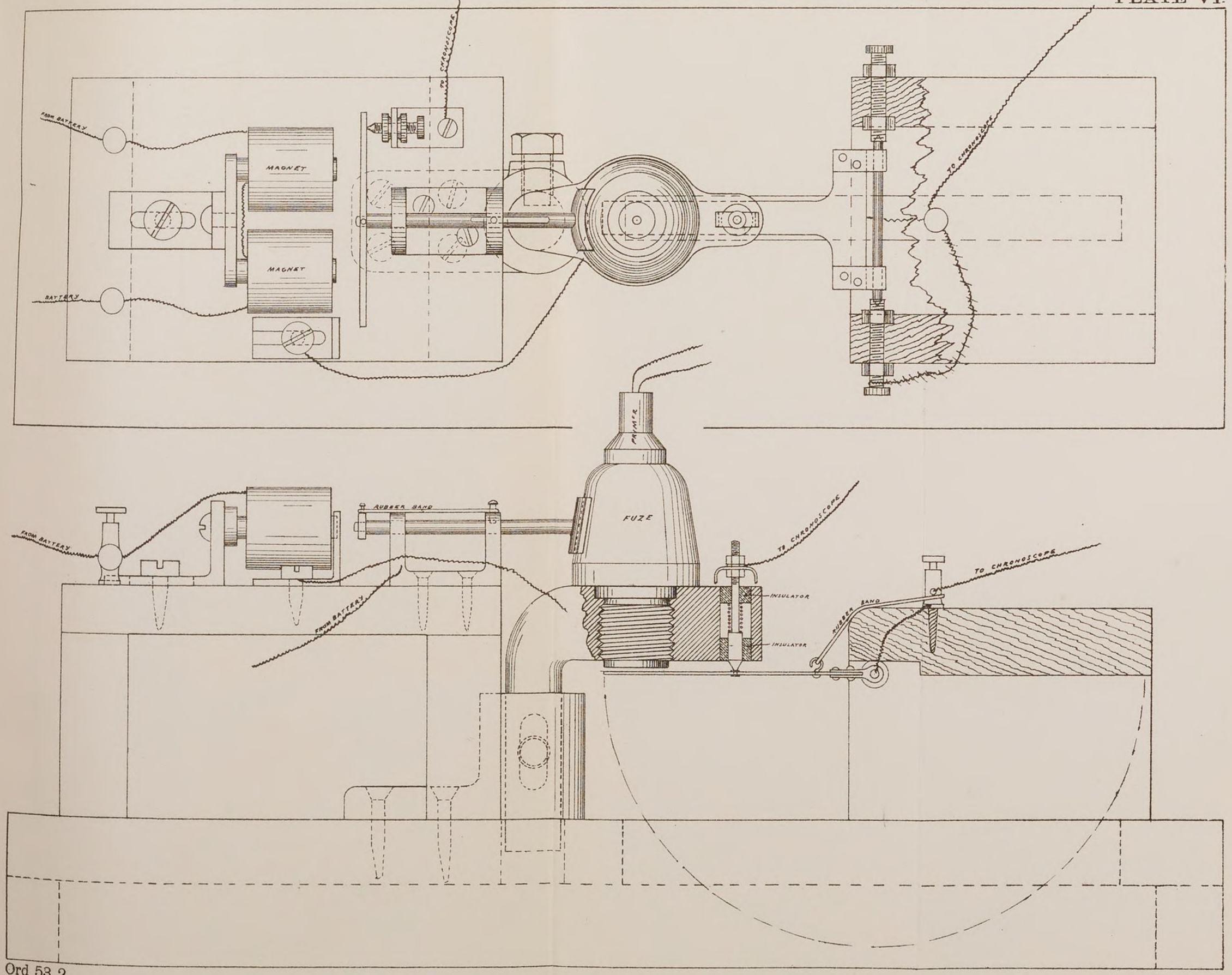
Springfield Rifle Cal. .45

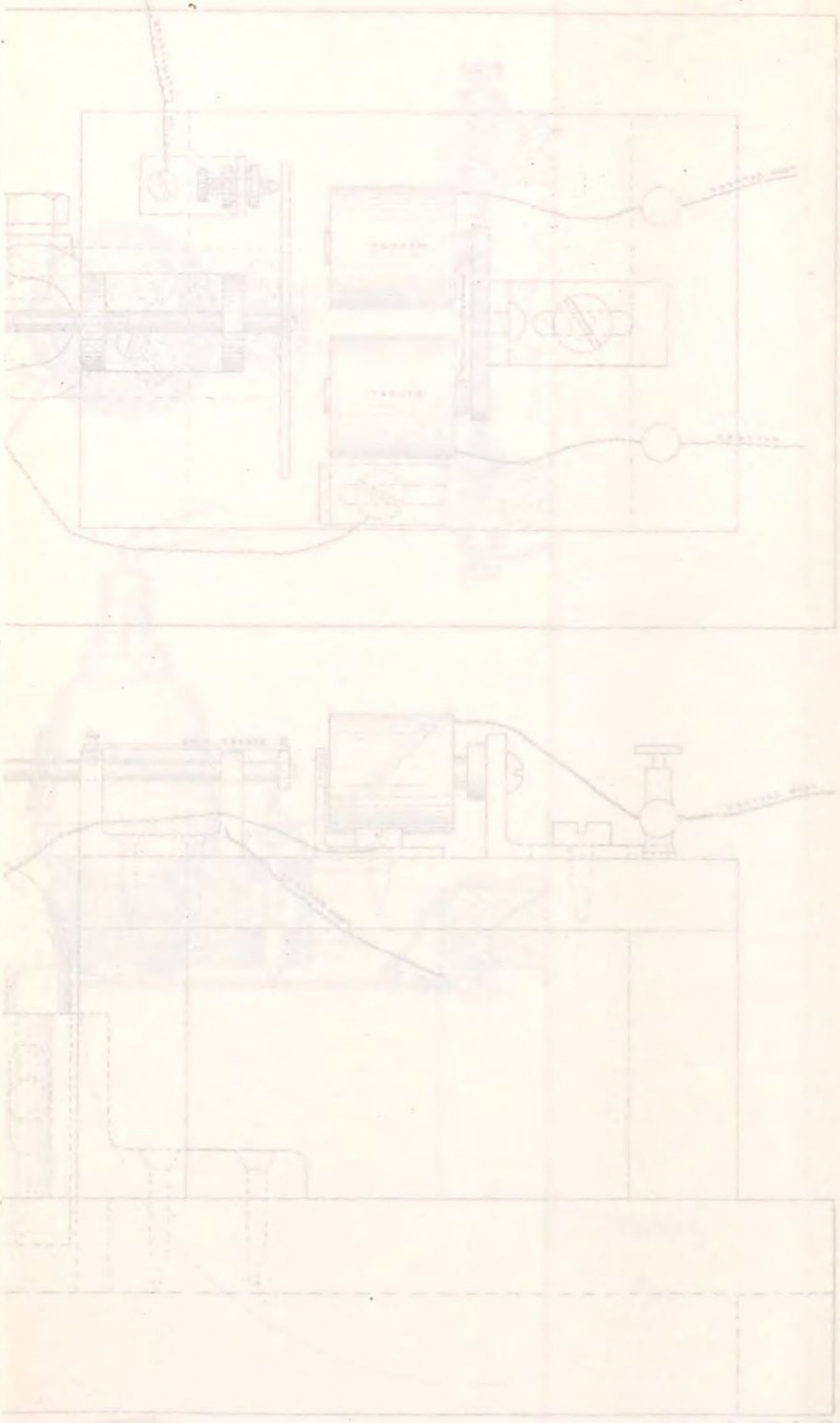
Charge 67 grs. Dupont — 500 grs. Bullet — Initial velocity 1300 f.s.



Carr's Fuze timing device.

PLATE VI.





APPENDIX 21.

REPORT OF PRINCIPAL OPERATIONS AT WATERVLIET ARSENAL FOR THE FISCAL YEAR ENDING JUNE 30, 1893.

(10 plates.)

BUILDINGS, PLANT, AND OTHER CONSTRUCTION WORK.

GUN FACTORY.

A concise description of the gun-factory building and its equipment has been given in the annual reports of my predecessor. The work of equipping the south wing with machinery and appliances has been carried on progressively with the delivery of the tools.

In addition to the hoop lathes and other tools reported as having been delivered last year, the following large machine tools for 12-inch gun work have been put in place: Two boring and turning lathes, 6 turning and finishing lathes, 1 threading and slotting machine. Two boring and turning lathes for 12-inch gun work are in the course of erection by the Niles Tool Works.

The total number of gun lathes and other large machine tools for the finishing and assembling of 12-inch guns in the south wing comprises: Six boring and turning lathes, for guns of 40 feet length; 6 turning and finishing lathes, for guns of 40 feet length; 1 rifling machine; 1 threading and slotting machine for breech screws.

The hoop lathes and other tools which were delivered last year have been in continuous operation for several months, and they have given entire satisfaction as to the quantity and quality of the work performed in them.

The following machine tools for the finishing and assembling of 16-inch guns, which were mentioned in the last annual report, have been delivered and erected: Two lathes, 16 inches swing; one 72-inch vertical turning and boring mill; one slotting machine, 18-inch stroke; one open side planer and shaper; one Universal milling machine with automatic attachment for threading translating rollers, and one 60-inch automatic gear cutting machine.

Two hoop lathes of 80 inches swing and one hoop lathe of 60 inches swing, for boring and turning 16-inch gun hoops up to 15 feet length, are in the course of manufacture by the Pond Machine Tool Company.

The assembling and finishing of 12-inch gun work is intended to be carried on in the south wing exclusively.

Work of this class that has heretofore been performed in the north wing has been in a large measure transferred to the south wing. This transfer of work will be completed as soon as possible, after which the north wing will be exclusively used for 8 and 10 inch guns, for the handling of which two 30-ton traveling cranes have been provided in that wing.

In the south wing there is at present only one traveling crane, of 120 tons capacity, in operation, but proposals have been issued for one electric traveling crane of 60 tons capacity and 60 feet span, to run on the same crane ways as the 120-ton crane, and for one 30-ton traveling crane of 20 feet span for the west aisle. The 60-ton crane is to be used for handling all loads up to its capacity, while the 120-ton crane will be used principally for heavier loads and for shrinkage operations.

Proposals for a portable scale of 300,000 pounds capacity have also been issued. This scale will occupy a very small space on the floor of the gun shop. When used it will be pushed under the crane carrying the gun and back against the wall after weighing. It is provided with six wheels with very broad tires. With this scale the work of weighing guns will be very much facilitated, because the 60-ton railroad scale now in use is located at a considerable distance from the gun shop and access to it is difficult in the winter.

Overhead travelers of 5 tons capacity, with differential hoists, have been put into the south wing, in the side aisles, and also into the central section. The latter are to connect the side aisles of the north and south wings, so as to transport hoops and other material up to 5 tons in weight through the building without the constant use of the large traveling cranes in the main aisle. For the same reason narrow-gauge tracks, with shop trucks, have been provided in four different localities, connecting the main aisles with the side aisles.

Of the large gun lathes in the south wing there are only three in operation with temporary back rests. A final decision as regards the character of the most suitable back rests for gun lathes has been reached after an exhaustive comparative trial of the back rests with rotating chuck rings and those with ordinary stationary dogs. The result of this trial was the adoption of back rests with rotating chuck rings, based on the fact that they will considerably shorten the work of finishing the guns, and therefore cheapen the cost, and that greater accuracy of the work can be obtained by their use. Orders for these back rests for 15 gun lathes have been given and their delivery is expected within a short time. On the whole, the plant is running very satisfactorily, and no changes have been found necessary after more than two years' operation.

Designs for 16-inch gun lathes and 16-inch threading and slotting machine are under preparation; also designs for so reconstructing the 12-inch rifling machine as to permit the rifling of 16-inch guns. These and the specifications will be forwarded at an early day.

The small gun shop (field and siege department) is in a satisfactory condition, but there are a few special machines required to make this shop independent of the large shop. Inasmuch as certain operations on field and siege guns must at present be carried on in machines designated for work on seacoast guns, the purchase of a horizontal drilling machine and of a large Brown & Sharpe milling machine is especially recommended.

The work on seacoast guns in the small shop has recently been discontinued because the large shop is amply provided with machines to carry on all of the work successfully, and its greater crane facilities lessen the cost of handling the guns.

In order to create much needed floor space for assembling the breech mechanism of field and siege guns, for fitting sights and other work, the upper parts of the large Springfield lathe have been dismounted and stored in shed L. The bed has been left in place and will be covered with temporary flooring. For some time before dismounting this

lathe it was known that some of the working parts were worn to such an extent as to interfere with the accuracy of work; the cost of repair would be considerable and there is no urgent necessity for it at present. The parts have been carefully marked and stored so as to assemble the lathe if future occasion requires it.

The 120-inch lathe and the 83-inch lathe in the small shop are still in good condition, and will be kept so for experimental and incidental work.

The 60-horse power Buckeye engine, which was not required for the operation of the small gun shop after provisions had been made to run its shafting from the line-shaft in the east aisle of the large shop, was sent to the Watertown Arsenal.

An oil house and a locomotive shed have been built west of the gun shop in suitable localities, and a plan for the storage of coal and the handling of coal and ashes is under preparation.

It is recommended that a room be prepared in the north end of shed L of sufficient capacity to store a two months' supply of iron, tool steel, and other material (except oil) for the gun factory.

Inasmuch as the equipment of the gun factory is practically drawing toward completion, and the arrangement of the plant has been finally decided upon, I submit with my report a plan of all the buildings, etc., comprising the gun factory, showing the location of machines and other appliances, etc., also photographs representing interior and exterior views of the different departments.

ELECTRIC LIGHT AND POWER PLANT.

Proposals have been invited for an electric light and power plant, to be procured from existing appropriations, which, when completed, will furnish great advantages.

Owing to a general leakage of gas throughout the whole length of the pipes it became necessary several months since to discontinue the use of gas on the grounds and in all of the buildings, including the officers' quarters. As there are no funds available for the repair of this line of gas pipe, this condition in regard to light must remain until the establishment of the electric plant, which, it is hoped, will be in operation by the 1st of November. This will be operated by available water power through turbines located in the shops east of the canal after the reconstruction of the present plant.

Water power will be required during the daytime to run the shops east of the canal, and also the electric traveling cranes in the gun shop.

Arrangements are provided to operate the lower shops by the steam-power plant of the gun factory by means of electric transmission, so as to take the place of the water supply from the Erie Canal, which is stopped periodically. This arrangement will provide against any inconvenience from such emergencies or repairs to the water-power plant.

The electric plant comprises therefore two stations, one of four 45-kilo Watt dynamos in the gun factory, and one of two 45-kilo Watt dynamos in the machine shop east of the canal. The former is operated by steam power and the latter by water power. Both plants are connected, and can be operated jointly or independently. Separate switches are provided for lighting the grounds, for lighting quarters, offices, and barracks, and for lighting all of the shops of the establishment; also for operating the electric traveling cranes.

The switches controlling the lighting of the grounds will be located in the guard-house; 50-candle power incandescent lamps will be used exclusively for this purpose.

There is no doubt that the installation of the electric plant will result in great economy, at least as far as the utilization of the water power for operating shops and cranes is concerned. Plans showing the general arrangement of the plant and the distribution of lights are appended; also the specifications.

WATER-POWER PLANT.

The present condition of the water-power plant at this post is very deplorable and has been for years. The plant was established many years ago and on a plan inconsistent with modern intelligence and progress. Turbines have been located in the different shops from time to time. They are all badly worn and have been repeatedly repaired in recent years. The present arrangement of turbines does not admit of the utilization of more than one-third of the available water power. Appropriations have been asked for yearly, but were granted only at the last session of Congress. The sums appropriated do not equal the estimate of the cost, as has been previously reported to you, and an additional sum will be needed to secure satisfactory results. The plan, approved by you during your last visit, is to remove the old and locate four new turbines, each of 30-horse power capacity, on the site of the present two water-wheels in the machine shop. The electric station will be on the first floor above it. The new arrangement will no doubt furnish great conveniences and reduce expenses.

PAVEMENTS, ROADS, BRIDGE, ETC.

That part of Broadway which is situated between the western rail of the electric railroad and the curb was paved last year with granite blocks to the whole extent of the arsenal frontage. An additional appropriation now available will permit the paving of the eastern side of Broadway. Specifications and plans for this work have just been forwarded and are awaiting your approval. The work will be done within the next two or three months. After that this road will have been paved over its entire extent, except that portion between the electric railway tracks, which will, I presume, be paved by the railroad company at some future day, the company having declined to do it now.

Paving with granite blocks inside the arsenal grounds was continued during the past year to the extent of the appropriation available. But there is still much to be done in this direction, so that the shops may be accessible for heavy teams in bad weather. The amount asked for in my annual estimate submitted to you is much needed.

The grounds in front of the administration building are low and are flooded during freshets. This not only produces unhealthy conditions, but the contaminated water of the Dry River, which carries the sewerage of the upper part of the village, overflows the only well on the post from which water fit for domestic purposes can be obtained. A part of these low grounds has been filled in. An appropriation is requested to complete this work.

The old wooden bridge across the Erie Canal, which is too light for the purposes of this establishment and exposed to danger of fire from sparks of canal tug-boats or other sources, and the roof of which was damaged by fire last year, is to be replaced by a suitable iron bridge. Specifications and drawings for this new bridge have been submitted for your approval.

WATER SUPPLY.

The present water supply of the post is obtained from the river by pumping the water into an old reservoir on the hill west of the gun factory and by connections with distribution system of the West Troy water works. Neither plan furnishes water fit for domestic purposes. As the water furnished by the West Troy water works is filthy in the extreme, and had to be shut off even for manufacturing purposes, water for the latter purpose is pumped from the river, while that destined for domestic purposes is taken from a well and is delivered to the buildings in casks.

It has been found that a stream of water can not be thrown on the roof of the gun factory by turning on the city water, on account of insufficient pressure.

In view of all these reasons I have requested an appropriation to obtain an independent supply of water for all purposes. This can be done by erecting a water tower of lattice work, carrying on top a reservoir at sufficient elevation to protect the gun factory in case of a conflagration, with a second reservoir placed beneath the first one and enough space between the two for two large filters. All water would then be pumped from the Hudson River into the upper or settling reservoir. The water on leaving this reservoir passes through the first filter and thence into the distributing pipes for manufacturing purposes. Water for domestic purposes is furnished by passing from the first filter through the second one, and from the latter into the lower reservoir. This arrangement of the distributing system allows division of the supply for manufacturing and domestic purposes.

The following specifications were prepared or issued during the past year and copies are attached hereto:

(1) Specifications for machine tools for the 16-inch plant. (2) Specifications for an electric light and power plant; (3) specifications for a 60-ton electric traveling crane; (4) specifications for a 30-ton electric traveling crane; (5) specifications for a 300,000-pound gun scale, etc., all under one cover. (6) Specifications for granite-block pavements. (7) Specifications for an iron wagon-bridge across the Erie Canal.

I forward also a paper prepared by Mr. Anthony Victorin, constructing engineer at this arsenal, on the performance of the 120-ton single-motor electric traveling crane at this arsenal. This paper was presented at the last fall meeting of the American Society of Mechanical Engineers, and recommends itself for publication by the Department. An appendix contains tests made with a three-motor electric traveling crane also.

Also report of Capt. Hobbs on construction of 3.6-inch mortar platforms.

GUN CONSTRUCTION.

The construction of field, siege, and seacoast cannon has been continued during the year in the gun shop. The work completed and that in progress at the beginning and end of the year is exhibited in the following table:

Caliber and kind of cannon.	Construction in progress June 30, 1892.	Completed June 30, 1893.	Construction in progress June 30, 1893.
3.2-inch B. L. rifle, service	25	1	49
3.6-inch B. L. rifle, service	24	2	22
3.6-inch B. L. field mortar, service	16	16	.....
5-inch B. L. siege rifle, service	10	10	10
7-inch B. L. siege howitzer, service	10	10	10
7-inch B. L. siege mortar, type	.....	.....	1
8-inch B. L. seacoast rifle, service	.....	.....	12
10-inch B. L. seacoast rifle, service	12	12	11
10-inch B. L. rifle, Woodbridge, wire-wound	1	1	.....
10-inch B. L. rifle, Crozier, wire-wound.	1	.....	1
12-inch B. L. seacoast rifle, service	4	3	6
12-inch B. L. seacoast mortar, steel, service	.....	.....	2

Many of the guns noted as in progress of construction are well advanced towards completion and will be finished by the end of the calendar year, viz: Twenty-three 3.2-inch B. L. rifles, twelve 8-inch B. L. rifles, seven 10-inch B. L. rifles, one 10-inch B. L. rifle (Crozier, wire-wound), and five 12-inch B. L. rifles.

There will then have been completed in the gun factory since the beginning of operations 198 cannon of various calibers, as follows, viz: One hundred and one 3.2-inch B. L. rifles, seventeen 3.6-inch B. L. mortars, one 3.6-inch B. L. rifle, ten 5-inch B. L. rifles, ten 7-inch B. L. howitzers, twenty-five 8-inch B. L. rifles, twenty 10-inch B. L. rifles, three 10-inch B. L. rifles (wire-wound), nine 12-inch B. L. rifles, one 12-inch B. L. mortar, and one 12.2-inch B. L. mortar (converted).

The supply of forgings on hand at present is ample, and if the sets of forgings now contracted for are delivered at the times specified in the contracts these forgings, together with those on hand, will permit the gun factory to produce during the calendar years 1894 and 1895 the number of completed service seacoast guns called for in the table of estimated output.

But to enable the factory to construct the guns scheduled in the output table for the calendar year 1896, an additional supply of forgings will be needed during the year 1895; otherwise, work will practically cease during the year 1896 unless it be decided in the mean time to limit the output to a less number of guns than is given in the table, thereby requiring many machines to lie idle and increasing the cost of production.

It seems proper to state here that experience in the factory as it approaches completion and the extent of the facilities it offers becomes evident, shows its capacity, working eight hours per day, will exceed the estimated output.

The cost of guns has not been above the estimates submitted to you.

Much work has been done during the year, besides the manufacture of new service guns, in the way of alterations and repairs and fabrication of parts of guns.

During the year the introduction of a definite system of work has been commenced and shop regulations for the government of employés have been introduced from time to time, as the necessity therefor has been foreseen or has arisen. As the installation of plant more nearly approaches completion and becomes more nearly a fixed factor, the system and regulations can be more nearly complete and can be more exactly carried out and enforced. It is believed that before the close of another year the work will be progressing as smoothly, economically, and expeditiously as can be expected.

The following schedule gives the progress made during the past year in the manufacture of caissons and limbers for 3.2-inch B. L. rifle, steel, combined forges and battery wagons, and mortar carriages:

Articles.	In progress June 30, 1892.	Completed June 30, 1893.	In progress June 30, 1893.
Caissons and limbers for 3.2-inch B. L. rifle, steel	25	25	.....
Combined forges and battery wagons	6	6	.....
Carriages, caststeel, for 3.6-inch B. L. field mortar, steel	11	9	2

The manufacture of these articles has been reduced to the completion of previous orders since the transfer of this class of work to the Rock Island Arsenal.

PROJECTILES.

The manufacture of projectiles has been continued in the shops below the canal during the past year. The amount of this work has been considerably diminished on account of the transfer of the manufacture of the heavier projectiles to Watertown Arsenal. There are still a few large projectiles to be completed, but the number is not sufficient to permit the manufacture to be prosecuted on an economical basis, and as soon as the work in hand is finished the foundry and the projectile finishing shop will be closed. This will, however, not prevent the plant from being kept in good condition for work when required in the future.

The following schedule gives the progress made during the past year in the manufacture of cast-iron projectiles:

Kind of projectiles.	In progress June 30, 1892.	Completed June 30, 1893.	In progress June 30, 1893.
3.2-inch shells	3,000	6,278	269
3.6-inch shells	600	2,102	851
5-inch shells	1,000	1,624	135
7-inch shells	.....	19	259
8-inch shells (Eureka)	.....	7	.....
12-inch shells (800 pounds)	30	37	80
12-inch shells (1,000 pounds)	.....	.....	20
8-inch shot (300 pounds)	.....	7	.....
12-inch shot (1,000 pounds)	50	100	.....

Besides cast-iron projectiles, twenty-five 11-inch experimental steel shell (from castings) and twenty-five 12.2-inch mortar shells (from forgings) have been manufactured.

In addition to the above work, the buildings, grounds, roads, and walks have been kept in good order and condition as far as was practicable with the limited appropriation available for this purpose. The receiving and issuing of stores and material has in all cases received prompt attention. The carrying out of all the work has been successfully accomplished under the supervision of junior officers who have been placed in charge of the same, each officer being assigned a specific portion of the work. All of them are entitled to great credit for their earnest and faithful performance of the duties allotted to them. They are deserving of great credit for the manner in which they have familiarized themselves with the special duties required at this arsenal, taking into consideration the short interval of time that has elapsed since they were assigned to such duties.

Mr. Anthony Victorin, the constructing engineer, and Mr. Alfred Christiansen, the master mechanic, are deserving of special mention for faithful and skillful performance of their manifold duties.

Miscellaneous stores fabricated in addition to field, siege, and seacoast guns and mortars, field carriages, and projectiles.

CLASS 3.

12 buckets, water, galvanized iron.
3 gunners' reamers } for 3.2-inch B. L. rifle.
1 gunners' gimlet }
32 handspikes for 3.6-inch B. L. field mortar carriage, steel.
1 set implements and tools for breech mechanism of 12-inch B. L. mortar.
5 lanyards, new pattern.
1 loading tray for 8-inch B. L. rifle.
4 maneuvering handspikes with spring attachments for 3.2-inch rifle carriage limber.
25 prolonges section of picket rope.
9 priming wires for 3.2-inch rifle, steel.
3 pouches, sight, new pattern, for 8-inch converted rifle.
1 quoin for 8-inch siege howitzer.
5 scrapers for cannon, outside.
6 tompions, metallic, for 8-inch converted rifle.
4 tompions for 15-inch guns.
11 vent punches for 3.2-inch B. L. rifle, steel.
6 vent covers for 3-inch rifle.
2 vent pieces, 6-pounder gun (Ames).
2 vent pieces for light 12-pounder gun (C. A. & Co.).
2 vent pieces for light 12-pounder gun (R. C. Co.).

CLASS 8.

700 blank cartridges for 6-pounder gun.
3,153 blank cartridges for light 12-pounder gun (for morning and evening gun).
690 blank cartridges for 3-inch rifle.
449 blank cartridges for 3.2 inch rifle ($2\frac{1}{2}$-pound charge).
160 blank cartridges for 2.2-inch rifle ($3\frac{3}{4}$-pound charge).

CLASS 9.

16 platforms for 3.6-inch B. L. mortar carriages.

CLASS 10—PARTS CLASS 1.

1 elevating band for 8-inch B. L. rifle No. 4.
3 gas-check pads for 3.2-inch Gerdom gun.
3 gas-check pads for 5-inch B. L. rifle.
1 gas-check pad for 8-inch B. L. rifle No. 4.
5 gas-check pads for 8-inch B. L. rifle manufactured at West Point Foundry.
5 gas-check pads for 8-inch B. L. rifle No. 1, Watervliet Arsenal.
4 gas-check pads for 10-inch B. L. rifle.
4 gas-check pads for 12-inch B. L. rifle.
5 gas-check pads for 12-inch mortar, steel.
1 gas-check pad for 12-inch cast-iron mortar, steel-hooped.
2 gas-check pads for the Brown segmental gun.
6 hinge-pin screws for 3.2-inch B. L. rifle.
1 hinge-pin for console for 8-inch rifle.
1 handle for rotating breechblock for 8-inch rifle.

PARTS CLASS 2.

2 bronze screw lids or primer-box lids for primer-box, 3.2-inch caissons.
1 corrugated plate model for 3.2-inch rifle limber.
5 canvas covers for ammunition chests, 3.2-inch rifle.
1 chain and stay pin for ammunition chest for 3.2-inch rifle carriage limber.
8 sets fittings for ammunition chests for 3.2-inch field gun, limbers, and caissons.
1 handspike spring attachment for 3.2-inch caisson.

4 hooks for securing spare poles for 3.2-inch rifle carriage.
4 keys, chains, and eye rivets for 3.2-inch caissons.
2 linch pins, new model, for 3.2-inch rifle carriage.
2 linch washers, new model, for 3.2-inch rifle carriage.
2 leather straps for ammunition-chest lid.
2 pieces of copper for 3.2-inch limber poles.
4 pole props for rear of pole.
5 pole props for end of pole.
4 spring jaws for securing maneuvering handspikes.
13 turnbuckles for 3.2-inch ammunition chests.
50 washers for artillery wheels.

Parts Class 3.

2 pole pads, rubber, for 3.2-inch limber.
6 neck-yoke pads, rubber, for 3.2-inch limber.
23 pole pads, leather, for 3.2-inch limber.
9 pole pads, rubber, for Hotchkiss field carriage.
2 pads for end of yoke, leather.
2 rammer heads for long rammer staff, 3.2-inch rifle.

Parts Classes 4 and 5.

400 base plugs for projectiles for Hotchkiss 6-pounder rapid-fire gun.
1,000 base plugs for projectiles for Driggs-Schroeder and Seabury rapid-fire guns.
150 copper bands for rebanding 12-inch shells.
15 copper bands for 3.2-inch B. L. rifle shells.

PART SECOND.

Paints, Oils, Dyes, etc.

39 pounds paint for 3.2-inch rifle.
749 pounds paint for 3.2-inch rifle carriages, caissons, and limbers.

Inspecting Instruments, etc.

1 rolling table.

Miscellaneous Articles.

161 boxes packing.
1 wooden model of the shell for 3.2-inch field gun.

Tools, Utensils, and other Miscellaneous Articles.

12 aprons, smiths'.
6 coal bags, 3 bushels.
6 grindstones, arbor cranks and frames, iron, complete.
6 oil cans, sperm, 2¼ pints.
1 oiler for Gatling gun, caliber .45, model 1883.
1 screw-driver for sight for 10-inch rifle, steel.
1 screw-driver, for hinge-pin screws for 10 and 12 inch rifle.
1 screw-driver for oil-hole screws for 10 and 12 inch rifle.
1 screw-driver for securing latch screw for 10-inch rifle.
1 screw-driver for securing latch screw for 12-inch rifle.
12 shoeing boxes sole leather.
36 tool bags (small canvas bags) for nails and small stores.
1 set templets (6) for 8-inch guns, to be used with step gauge.
31 wheel grease cans.
32 wheel grease can knives.

UNFINISHED WORK IN HAND.

Class 8.

355 cartridges for light 12-pounder gun.

CLASS 10.

Parts appertaining to Class 1.

43 gas-check pads for 12-inch B. L. mortars, cast-iron, steel-hooped.

Parts appertaining to Class 2.

1 ammunition chest, experimental, for 3.2-inch B. L. rifle carriage.
152 sets fittings for ammunition chests for 3.2-inch field-gun limbers and caissons.

OTHER WORK DONE.

CLASS 1.

4 3.2-inch B. L. rifles, steel, West Point Foundry series, and 2 3.2-inch B. L. rifles, steel, Watertown Arsenal series, altered from Freyre gas-checks to De Bange gas-checks, and fitted with automatic vent-closers.
1 English volley gun cleaned and prepared for issue.

CLASS 2 AND PARTS CLASS 2.

21 30-pounder Parrott siege carriages and 19 limbers changed to receive the 4½-inch rifle.
1 24-pounder carriage and limber repaired and altered to 8-inch siege howitzer.
1 English volley gun, caliber .50, painted and repaired for issue.
6 caissons and limbers for 3.2-inch rifle repaired and reënforced.
6 carriage limbers for 3.2-inch rifle repaired and reënforced.
46 frames or bodies for 3.2 inch caissons repaired and reënforced.
9 frames or bodies for combined forges and battery wagons repaired and reënforced.
1 metallic Gatling-gun carriage, caliber .45, altered for old pattern harness.

Respectfully submitted.

ISAAC ARNOLD, JR.,
Major, Ord. Dept., U. S. Army, Commanding.

WATERVLIET ARSENAL, *August 21, 1893.*

(4772–'93.)

SPECIFICATIONS FOR PAVING WITH GRANITE BLOCKS THE HIGHWAY (BROADWAY) IN FRONT OF THE WATERVLIET ARSENAL, WEST TROY, N. Y.

Plan and profiles of the pavement to be constructed are shown on the accompanying blue print, marked A.

The total length of the pavement will be 1,646 feet; its width will be about 10 feet (including curb). The granite pavement will not extend close up to the rail, but only as far as the ties will permit—say within 1 foot.

In addition, there are two localities (first, opposite the small gate, second, opposite the main gate) where granite pavement has been laid to the extent figured on the plan.

The curb forms a straight line between points *a* and *b*, whence it runs converging in straight lines to join the terminals of the existing village curb at *c* and *d*.

The profile of the curb is shown in the blue print. The gutter runs along the curb from end to end, and its profile is shown in the accompanying blue print. There will be two outlets or discharges, one into Dry River at *f* and the other into the culvert at *g*. Both outlets must be made of heavy cast-iron pipe, 10 inches in diameter, descending from the bottom of the gutter and passing through the masonry arches of

the Dry River and the culvert, vertically, if practicable, or by means of bends, if the condition of the arches should demand it. The top of each discharge pipe must be provided with proper removable gratings. Both discharges must be located without the curb line, and not in the road bed, and standard cast-iron catch basins will be furnished at these places.

The cross walk opposite the small gate will be taken up and a heavy 6-inch cast-iron pipe will be furnished by the contractor, running from the curb on the west side of Broadway to the wooden fence on the east side. This pipe will have such grade as will be directed. It must be laid perfectly straight, and the pavement and crossing stones will be properly relaid on top of said pipe. A vitrified pipe connecting with the eastern terminus will be laid by the Department.

Opposite the main-gate crossing a heavy cast-iron pipe, 10 inches in diameter, will be laid beneath the pavement from *h* to *i*, having a total length of 30 feet. To do this the contractor will take up the present paving as far as required and replace the same after laying the pipe. Both ends of this pipe must be provided with suitable removable gratings corresponding with those in place on the east side. The pipe must be properly bedded and must correspond with the grade of the gutter. An 8-inch heavy cast-iron pipe will be laid underneath the railroad crossing in a similar manner, with removable gratings at each end.

The interfering trees near the ferry crossing and all interfering telegraph, telephone, and wire poles will be removed upon action of the village authorities.

The grade of the granite pavement, at is crown, will follow the grade of the adjoining rail, and all other grades and levels will be given by the Department, which will furnish and set also all grade stakes and line stakes. If any doubt exists on the contractor's part in respect to the grade of any part of the work he will apply to the commanding officer before execution for proper directions.

All materials, also all labor of any kind, and all tools and appliances required for the proper prosecution of the work, must be furnished by the contractor.

The road-bed will be excavated to a depth of 17 inches below the surface of the finished pavement or gutter, and the cost of all excavation shall be included in the price paid for the pavement.

The material to be excavated consists of a mixture of dirt and macadam. At the bottom of this will be found yellow clay. None of the excavated material must be used in the construction of the new work.

All excavated material must be removed immediately from all along the line of the work by the contractor. It will be deposited in the vicinity of the road, within the arsenal inclosure, as will be directed by the commanding officer. All such material must be leveled and graded neatly by the contractor wherever deposited, and as far as possible the excavated earth or other soft material should be put on top of the fillings.

All existing flagging and curbstones which have to be removed will be left by the contractor temporarily along side the work, to be removed, by the Department.

The road-bed must be excavated to a depth of 17 inches below the surface of the finished pavement. Should there be any spongy material or vegetable matter in the bed thus prepared it shall be removed and the space filled with broken stone, and carefully rammed, so as to make such filling compact and solid. All roots of trees interfering with the work or its proper execution must also be removed.

No plowing will be permitted.

The entire road-bed, after having been brought to the required sub-grade, shall be rolled with a heavy steam roller weighing not less than 10 tons (more, preferably), until the surface is firm and compact. The ground must be sprinkled before rolling, except when otherwise directed.

On the road-bed so prepared must be put two layers of sound broken stone of approved quality, 2½-inch ring, each layer to be 3 inches thick, making a total of 6 inches of broken stone. As each layer is spread out it must be firmly rolled down with the steam roller till the mass will not yield under the roller. Sand must be washed into the stone-bed in order to fill the interstices.

A sand-bed is to be prepared on top of the foundation of broken stone 3 inches thick. The sand must be clean and sharp, without an admixture of pebbles, gravel, or clay.

On the sand-bed so prepared the stone blocks will be laid. The stone blocks must be of a durable, sound, and uniform quality of granite, each measuring on the face or upper surface not less than 8 inches nor more than 12 inches in length, and not less than 3½ inches nor more than 4 inches in width, and not less than 7 inches nor more than 8 inches in depth. Such stone blocks must be split and dressed so as to form, when laid, close end-joints and side-joints, not exceeding 1 inch wide top and bottom, with fair and true surfaces on top, bottom, and ends, and they are to be equal in all respects to the specimen blocks deposited with the commanding officer.

All stone blocks will be inspected, and any rejected stones shall be removed immediately, by the contractor, from the line of the work. The stone blocks must be laid at right angles with the line of the road, except in special cases, when they shall be laid at such angles and with such crown and such grade as will be directed. The first course adjoining the rail of the car-track and the first 3 courses adjoining the curb will be laid lengthwise; the latter for the gutter, the former a blind curbing.

Each course of blocks shall be uniform in width, and so laid that all longitudinal joints shall be broken by a lap of at least 2 inches, and that all such joints shall be as close as possible.

As the blocks are laid they shall be covered with clean fine sand, which shall be raked till all the joints become filled therewith; the blocks shall be thoroughly rammed to a firm, unyielding bed, with a uniform surface, to conform to the grade and crown of the road. No ramming shall be done within 25 feet of the face of the work that is being laid, and in doing all ramming the contractor shall employ one rammer to every two pavers. Whenever a suitable length of the road shall have been constructed as above described, it shall be covered with a good and sufficient second coat of clean, sharp sand, and shall immediately thereafter be thoroughly rammed until the work is made solid and secure.

The curbing shall be of the best quality of hard North River bluestone, not less than 6 inches thick and 20 inches deep, and not less than 4 feet long. It is to be quarried and axed, no indentations to exceed ¼ of an inch.

The trench for the curbing will be dug to the proper depth and wide enough to allow the earth to be rammed adjacent and underneath the stone. A bed of sand 2 inches in depth will be laid in the bottom of the trench and thoroughly consolidated by ramming.

On this bed the curb shall be laid to the levels and grades given by

the Department, the joints to be set close and the outer and inner surface to be set even and in a continuous plain surface, the first three inches above the bottom layer will be filled with gravel or sand, which will be rammed with rammers or bars so as to give the curb a solid bearing under its entire length; other layers of soil will then be rammed in the ditch to the surface of the ground, the layers of each ramming to be not more than 4 inches in depth.

The top of the cross-walk stones must project above the top surface of the granite pavement, as will be directed, and the elevation shall be in no case less than $\frac{1}{4}$ of an inch.

The length of the curbing is figured on the plan.

The approximate quantity of granite block pavement is 1,750 square yards.

The amount of work to be done may be increased or diminished in the discretion of the commanding officer, in view of the funds available for the purpose.

Bids must be made as follows:

1. A separate bid for furnishing and setting the curb. This bid must include also all iron pipes and fixtures having connection with the gutter, the two discharges, and the pipe laid under the road-bed at the small gate.

2. A bid per square yard for the granite block pavement, laid, complete as specified.

Payment will be made upon the completion of the whole work, or, at the request of the contractor, in two installments of 50 per centum each. No payment will be made for more than the full value of the amount of the work done by the contractor. The time for the completion of the work will be stated in the bid.

If any delay occurs in the completion of the work beyond the date specified, a reduction shall be made in the price thereof of $10 per day for each and every day (excepting Sundays) after said date until the completion of the work.

(4772–'93.)

PERFORMANCE OF AN OVERHEAD TRAVELING CRANE, OPERATED BY A SINGLE ELECTRIC MOTOR, AT WATERVLIET ARSENAL. BY ANTHONY VICTORIN, CONSTRUCTING ENGINEER.

The accompanying table contains data relative to the performance of an overhead traveling crane at the Army Gun Factory, Watervliet Arsenal, West Troy, N. Y.

The crane (built by the Morgan Engineering Company) is operated by a single electric motor. The electric current is generated by a Thomson-Houston 65-horse power dynamo. Its voltage is 500; the speed 1,020 revolutions per minute. The construction of the crane may be seen in *Figs. 1, 2,* and 3. It has a span of 60 feet, a clear hoist of 40 feet, and a capacity of 120 gross tons. The capacity of the auxiliary hoist is 10 tons, hoist 56 feet. The total weight of the whole crane is about 150 tons. The bridge rests on 8 double flanged wheels (4 on each side) of 36 inches diameter, the trolley on 16 wheels of 24 inches diameter. All wheels are arranged in pairs in compensating beams to avoid inconvenient results from want of uniformity in the level of the track rails. All wheels have also anti-friction steel roller bearings.

The motor *d* (Fig. 3) is located at one end of the bridge. It receives the electric current through a bare copper wire, *e*, which is strung on

insulated rollers along the crane ways. The motor is in permanent gear with the clutch-shaft, *c*. This shaft, *c*, is fitted with four clutch-gears.

Two square driving shafts, *a* and *b*, are located on the bridge, one on each side. Shaft *a* operates by means of clutches the bridge travel and trolley travel and the auxiliary hoist; while shaft *b* operates similarly the main hoist only.

The crane performs the following operations:

Bridge travel, 40 and 80 feet per minute.

Trolley travel, 50 and 100 feet per minute.

Main hoist, 2, 4, 8, and 16 feet per minute.

Auxiliary hoist, 20 and 40 feet per minute.

Automatic brakes are provided to sustain the load in any position.

The trolley is provided with two grooved chain-drums, each being capable of winding 250 feet of $1\frac{1}{4}$-inch wrought-iron main hoisting chain. These chain drums revolve loose on trolley axle shafts, 7 inches in diameter, with bronze-bushed bearings of 24 inches length at each end of drums.

The lower chain-sheave block contains 6 bronze-bushed sheaves of 30 inches diameter, while the upper block contains 5 sheaves of 33 inches diameter, each of which swivels independently of the others.

The chain is rove twelve times through the sheaves.

The chain-drum of the auxiliary hoist is located above one of the main chain-drums, and is grooved for a three-fourths-inch chain of sufficient length for 56 feet hoist.

The operating cage contains all manipulating levers, also the main switch, rheostat, etc.

All motions of the crane can be in operation simultaneously.

All gears of the crane mechanism are carefully cut, except the gears on the chain-drums, which are cast; all bearings have bronze bushings. All working surfaces are finished smoothly and all parts are carefully adjusted.

But notwithstanding all possible care with respect to the construction and the arrangement of the crane mechanism, a great percentage of the driving power is absorbed by friction—as indicated in the last column of the performance table—and the maximum efficiency of the main hoist is about 50 per cent; the lowest efficiency is about 23 per cent.

It may reasonably be assumed that the friction in the mechanism for the bridge travel and the trolley travel attains similar proportions as given for the hoist; and that the efficiency ranges from about 25 per cent for the lowest speeds, with the greatest number of gear trains in operation, to about 50 per cent for the highest speeds, with fewer parts in operation.

The figures in the table permit various calculations as to the frictional resistance in certain parts of the crane, *i. e.*:

Theoretical work of hoisting 120 gross tons 2 feet p. m	= 16.29	H. P.	= 24.3 amperes.
Actual work of hoisting 120 gross tons 2 feet p. m	= 40.2	H. P.	= 60.0 amperes.
Frictional resistance in crane	= 23.91	H. P.	= 35.7 amperes.
Actual work of operating hoist 2 feet p. m. without load	= 10.7	H. P.	= 16.0 amperes.
Frictional resistance due to the load of 120 tons	= 13.21	H. P,	= 19.7 amperes,

It was observed that the power required to bring the crane mechanism up to speed from the state of rest is considerable, and is from about 30 per cent to 150 per cent in excess of the power required for keeping an operation in continuance.

The table indicates also that no noticeable reduction or change occurred in the friction of the crane mechanism during a four-months' run from June 8, when the crane was first put in operation. The crane was in continual service during that period in handling various loads up to 60 tons. This may be an indication of good workmanship and large wearing surfaces.

Volts and amperes were actually measured in every test at the poles of the motor, and three independent readings were taken in each case. The figures given in the table represent therefore the average result of three tests. The maximum variation in the voltage of any test was less than five volts; hence the voltage was assumed to be practically constant. The only instant when the voltage fell as low as 490 occurred when a load of 30 gross tons was hoisted at a speed of 16 feet per minute. This test was omitted from the table, for the simplification and greater convenience of the latter. Observations were made in many instances at the poles of the generator also, simultaneously with those at the poles of the motor, especially with heavy loads; but the difference in the readings at both ends of the line was inappreciable, and about what was anticipated. The length of the line is about 1,000 feet, and the generator is located in the same building as the crane and at one end of the craneways. The instruments used were Weston direct reading standard ammeters and voltmeters.

The speed of the armature shaft of the generator was measured during many of the tests and under all conditions of load. The normal speed is 1,020 revolutions per minute; the slowest speed observed was 1,010 revolutions per minute, and the highest 1,064 revolutions per minute. Between these limits the speed was nearly constant under heavy loads. The average speed of 52 observations was 1,028 revolutions per minute.

The table contained in the advance copy of this paper, distributed before the meeting, was erroneous, because a calibration of the voltmeter, made after this table was printed, showed that it recorded 500 volts when it should have indicated 425 volts only. The interval of time between the calibration of the voltmeter and the date of the meeting enabled me to revise the table and to make a complete and new series of tests in order to verify the correction. The table herewith is thus corrected.

I have made a test recently, also, of a three-motor electric traveling crane, and present the data obtained, in the appendix, with such additional information as regards the description of the crane as was furnished me.

Performance of an overhead traveling crane, operated by a single electric motor, at the Army Gun Factory, Watervliet Arsenal, West Troy, N. Y.

[Voltage = 500.]

Operation.	Test of— June 8, 1892. Amperes.	Test of— June 8, 1892. E. H. P.	Test of— Oct. 8, 1892. Amperes.	Test of— Oct. 8, 1892. E. H. P.	Load.	Maximum amperage observed in starting. June.	Maximum amperage observed in starting. October.	Theoretical H. P.	Percentage of efficiency (October test).
Motor and clutch gears	4	2.7	4	2.7	No load.	.....	.....	.....	....
Square shaft for main hoist	7	4.7	6	4.0		.....	.....	.....	....
Square shaft for bridge and trolley travel	8	5.4	6	4.0		.....	.....	.....	....
Both square shafts	13	8.7	10	6.7		.....	.....	.....	....
Bridge travel:									
40 feet per minute	12	8.0	12	8.0		.....	25	.....	....
80 feet per minute	19	12.7	20	13.4		.....	45	.....	....
Trolley travel:									
50 feet per minute	12	8.0	10	6.7		.....	15	.....	....
100 feet per minute	18	12.1	18	12.1		.....	33	.....	....
Main hoist:									
2 feet per minute, hoist	12	8.0	12	8.0		.....	18	.....	....
2 feet per minute, lower	8	5.4	4	2.7		.....	18	.....	....
4 feet per minute, hoist	18	12.1	18	12.1		.....	50	.....	....
4 feet per minute, lower	11	7.4	8	5.4		.....	48	.....	....
8 feet per minute, hoist	23	15.4	26	17.4		55	60	.....	....
8 feet per minute, lower	10	6.7	6	4.0		35	45	.....	....
Auxiliary hoist:									
20 feet per minute, hoist	10	6.7	10	6.7		18	.....	.....	....
20 feet per minute, lower	9	6.0	8	5.4		.....	.....	.....	....
40 feet per minute, hoist	16	10.7	18	12.1		35	.....	.....	....
40 feet per minute, lower	13	8.7	14	9.4		30	.....	.....	....
Bridge travel, 40 feet per minute Trolley travel, 50 feet per minute	17	11.4	16	10.7		.....	42	.....	....
Bridge travel, 80 feet per minute Trolley travel, 100 feet per minute	24	16.1	24	16.1		.....	55	.....	....
Bridge travel, 40 feet per minute Trolley travel, 50 feet per minute Main hoist, 2 feet per minute, hoist	22	14.7	22	14.7		.....	40	.....	....
Bridge travel, 40 feet per minute Trolley travel, 50 feet per minute Main hoist, 2 feet per minute, lower	17	11.4	16	10 7		.....	.....	.....	....
Bridge travel, 80 feet per minute Trolley travel, 100 feet per minute Main hoist, 8 feet per minute, hoist	43	28.8	48	32.2		.....	80	.....	....
Bridge travel, 80 feet per minute Trolley travel, 100 feet per minute Main hoist, 8 feet per minute, lower	24	16.1	24	16.1		.....	.....	.....	....
Bridge travel:									
40 feet per minute	16	10.7	14	9.4		.....	30	.....	....
80 feet per minute	26	17.4	24	16.1		.....	55	.....	....
Trolley travel:									
50 feet per minute	12	8.0	12	8.0		.....	30	.....	....
100 feet per minute	24	16.1	20	13.4		.....	40	.....	....
Main hoist:									
2 feet per minute, hoist	24	16.1	26	17.4	30 gross tons.	.....	60	4.07	23.4
2 feet per minute, lower	3	2.0	2	1.34		.....	.....	.....	....
4 feet per minute, hoist	42	28.2	42	28.2		.....	80	8.14	28.9
4 feet per minute, lower	0	0	0	0		.....	45	.....	....
8 feet per minute, hoist	56	37.5	60	40.2		.....	110	16.29	40.5
8 feet per minute, lower	0	0	0	0		.....	45	.....	....
Bridge travel:									
40 feet per minute	18	12.1	16	10.7		.....	30	.....	....
80 feet per minute	24	16.1	24	16.1		.....	65	.....	....
Trolley travel:									
50 feet per minute	14	9.4	12	8.0		.....	23	.....	...
100 feet per minute	22	14.7	20	13.4		.....	65	.....	....
Main hoist:									
2 feet per minute, hoist	30	20.1	30	20.1	60 gross tons.	.....	55	8.14	40.5
2 feet per minute, lower	0	0	0	0		.....	30	.....	....
4 feet per minute, hoist	52	34.9	56	37.5		.....	70	16.29	43.4
4 feet per minute, lower	0	0	0	0		.....	60	.....	....
8 feet per minute, hoist	..	....	96	64.3		.....	.....	32.58	50.7
8 feet per minute, lower	..	....	0	0		.....	.....	.....	....
Bridge travel:									
40 feet per minute	16	10.7	18	12.1	120 gross tons.	.....	42	.....	....
80 feet per minute	32	24.1	36	24.1		.....	70	.....	....
Trolley:									
50 feet per minute	16	10.7	18	12.1		.....	35	.....	....
100 feet per minute	36	21.4	32	21.4		.....	65	.....	....
Main hoist, 2 feet per minute, hoist	64	42.9	60	40.2		.....	110	16.29	40.5
Main hoist, 2 feet per minute, lower	0	0	0	0		.....	45	.....	....
Auxiliary hoist:									
20 feet per minute	30	20.1	28	18.8	10 gross tons.	.....	.....	13.58	72.2
40 feet per minute	38	25.5	36	24.1	5 gross tons.	.....	.....	13.58	56.3

APPENDIX.

The following data represent the performance of an overhead traveling crane at the Pond Machine Tool Works, Plainfield, N. J.:

The crane is of the Shaw type, has a span of 41 feet, and a capacity of 15 tons. It is operated by a generator of 30-horse power; speed 750 revolutions per minute; built by the United States Electric Lighting Company, of Newark, N. J. The current is transmitted to the crane by means of two No. 00 (B. & S.) hard-drawn copper mains strung along the bridge. The operations of the crane are performed by three series-wound motors, built by the United States Electric Lighting Company.

The motor for the bridge travel is located at the end of the bridge, and is stated to be of 6-horse power. The motors for trolley travel and hoist are located on the trolley, the former, it was stated, having a capacity of 2-horse power, the latter of 8-horse power; voltage, 220.

The bridge rests on a truck on each end, having two double-flanged wheels of 24 inches diameter. The trolley rests on four double-flanged wheels of 14 inches diameter. The hoist motor drives a double-drum hoist by means of bevel gears and worms. The hoist has a break to stop the armature shaft after the current is broken. This brake consists of a pair of solenoids in series with the hoist motor that operates the halves of a friction clutch on the circumference of a drum of 7 inches diameter and 3 inches in width. The hoist is provided with a brake to prevent the load from driving the motor.

The speed of the motors is regulated by rheostats, the contact arms of which are operated in unison with the reverse switches by means of three levers in the crane cage. The reversing of the motor is accomplished by a reversing switch, which reverses the direction of the current in the armature.

No special attention was given to the condition of any part of the crane or the crane runways, as it was the intention to obtain data showing the results obtainable under ordinary conditions.

The figures given in the table are in each case the average of three independent readings or tests. Volts and amperes were actually measured at the poles of the motors in each case. The voltage was normal and constant during all tests except the one marked thus *, when it fell to 210. The instruments used were Weston direct reading standard ammeters and voltmeters.

Performance table of a 15-ton three-motor electric overhead traveling crane.

[Voltage = 220.]

Operation.	Amperes.	E. H. P.	Load in tons of 2,000 pounds.	Maximum amperage observed in starting.	Theoretical H. P.	Percentage of efficiency.
Bridge travel:						
250 feet per minute	16	4.7	.....	18	.....	.....
300 feet per minute	20	5.9	.....	48	.....	.....
75 feet per minute	16	4.7	5	35	.....	.....
300 feet per minute	22	6.5	5	75	.....	.....
60 feet per minute	18	5.6	10	.....	.....	.....
300 feet per minute	25	7.4	10	70	.....	.....
40 feet per minute	23	6.8	15	30	.....	.....
300 feet per minute	28	8.2	15	80	.....	.....

Performance table of a 15-ton three-motor electric overhead traveling crane—Continued.

[Voltage = 220.]

Operation.		Amperes.	E. H. P.	Load in tons of 2,000 pounds.	Maximum amperage observed in starting.	Theoretical H. P.	Percentage of efficiency.
Trolley travel:							
40 feet per minute		4	1.2	.....	6	.....	.....
100 feet per minute		5	1.5	.....	15	.....	.....
30 feet per minute		4	1.2	5	6	.....	.....
100 feet per minute		5	1.5	5	18	.....	.....
30 feet per minute		4	1.2	10	8	.....	.....
100 feet per minute		5	1.5	10	16	.....	.....
25 feet per minute		5	1.5	15	8	.....	.....
100 feet per minute		6	1.8	15	20	.....	.....
Hoist:							
25 feet per minute	hoist	15	4.4	.....	80	.....	.....
	lower	20	5.9	.....	.....	.....	.....
2.5 feet per minute	hoist	40	11.8	5	46	0.76	6.6
	lower	20	5.9	5	.....	.....	.....
15 feet per minute	hoist	33	9.7	5	100	4.54	46.4
	lower	20	5.9	5	65	.....	.....
3.5 feet per minute	hoist	43	12.7	10	.....	2.12	17.0
	lower	26	7.7	10	.....	.....	.....
15 feet per minute	hoist	53	15.63	10	82	9.09	58.0
	lower	26	5.9	10	65	.....	.....
3.5 feet per minute	hoist	66	19.46	15	84	3.18	16.0
	lower	26	7.7	15	30	.....	.....
10 feet per minute*	hoist	64	18.0	15	105	9.09	50.5
	lower	18	5.07	15	62	.....	.....

NOTE.—All speeds given in the above table for travel and hoist represent the maximum and minimum obtained for continuous work.

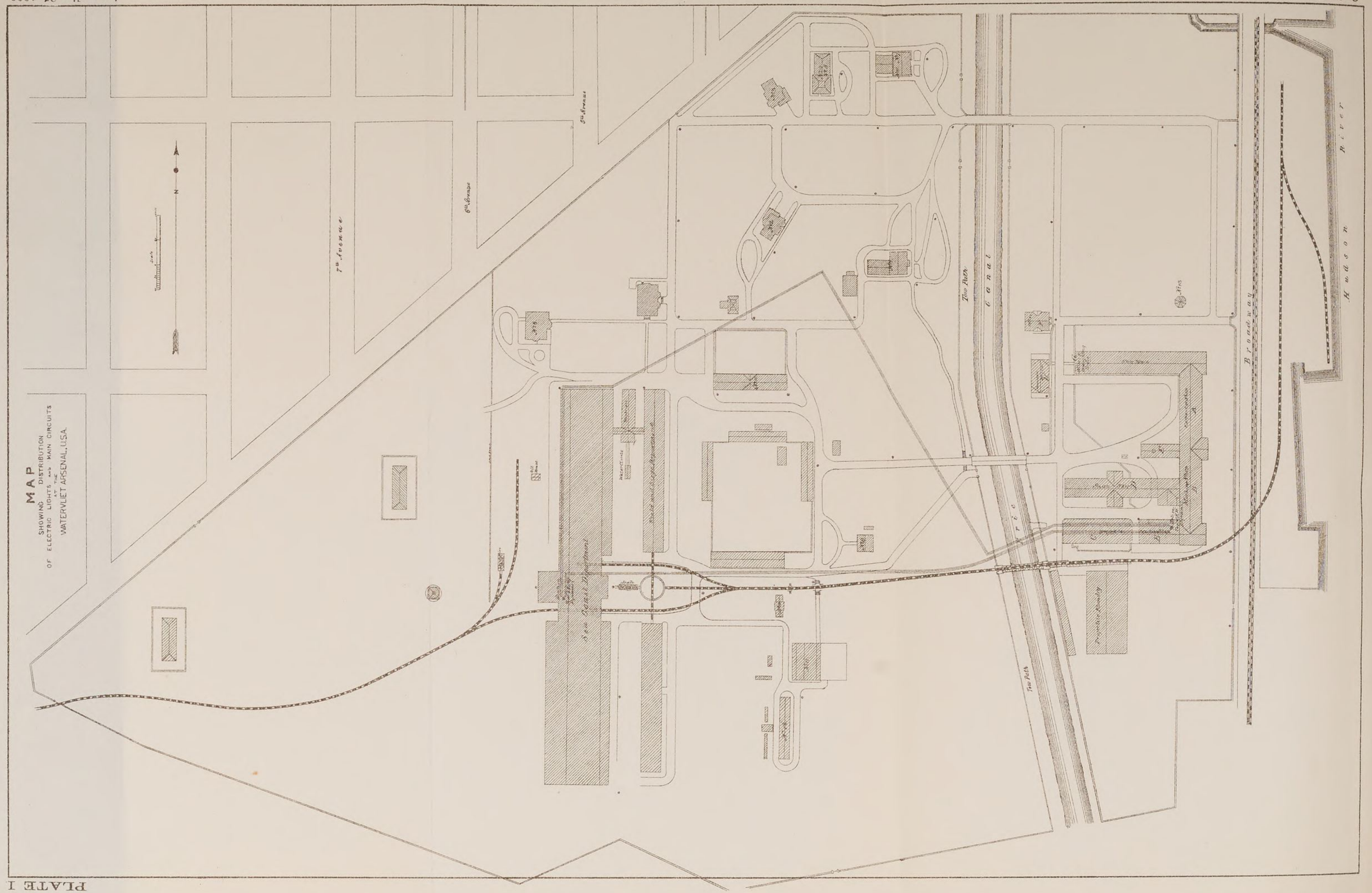
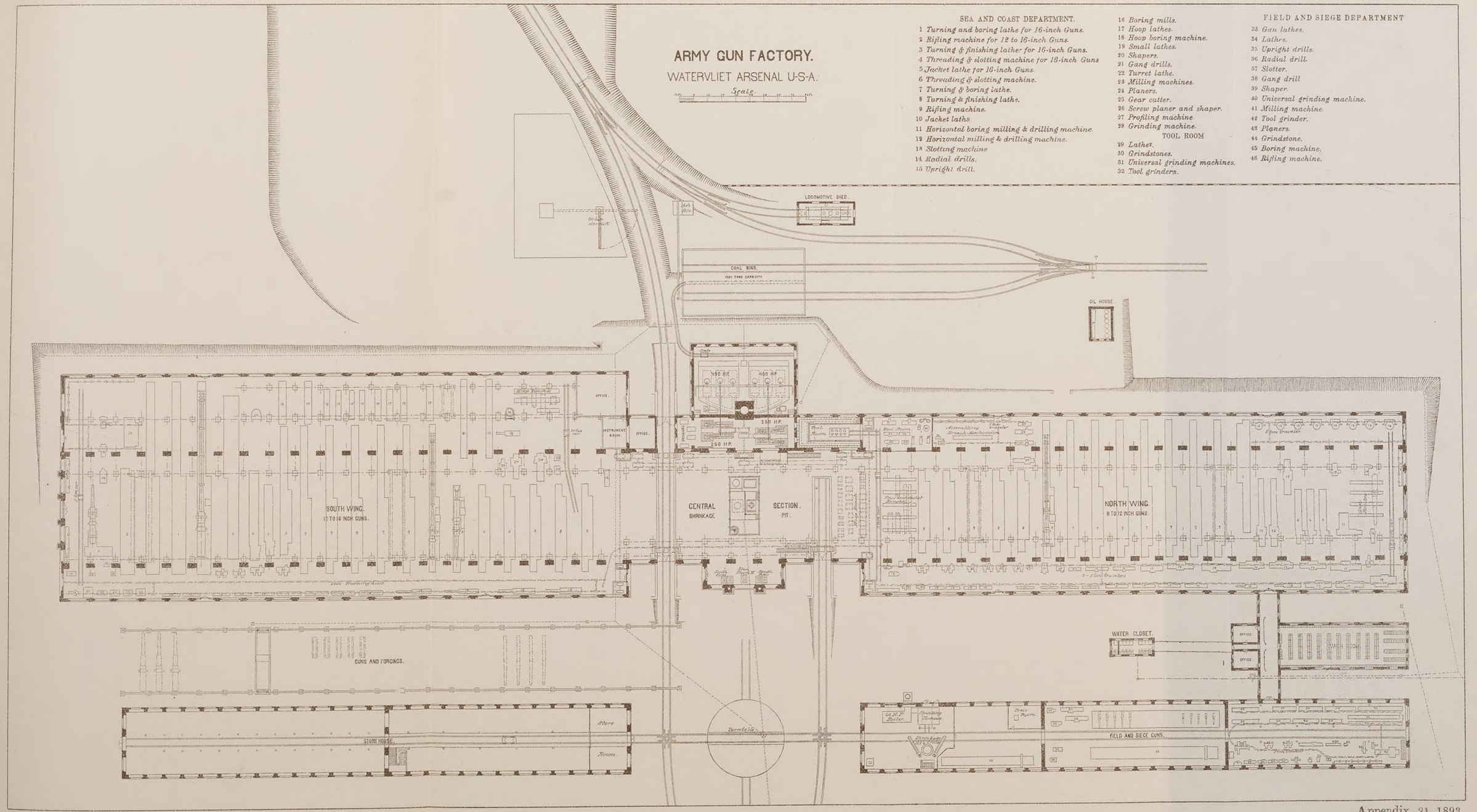
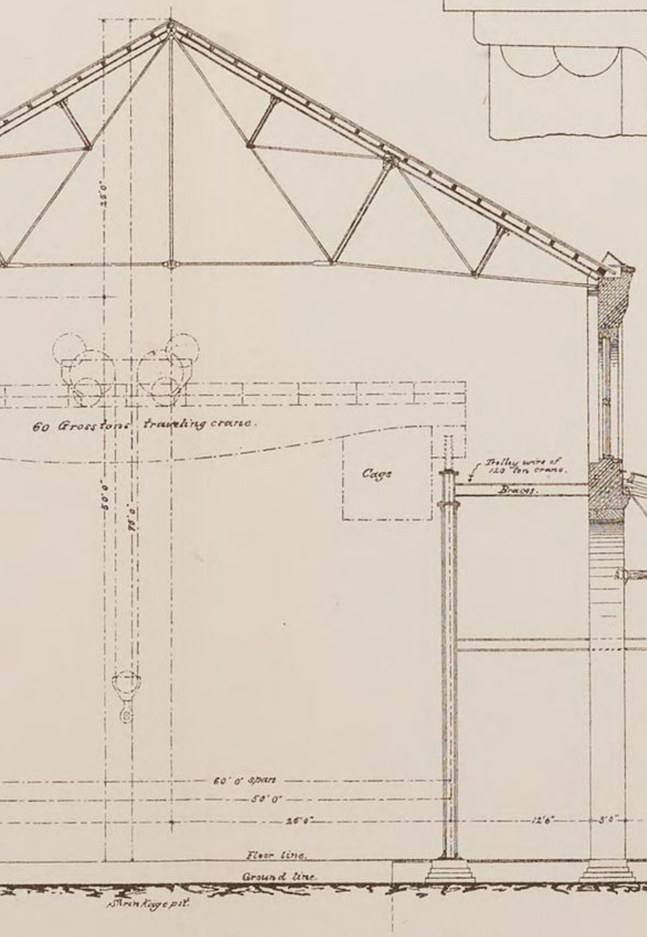

MAP
SHOWING DISTRIBUTION
OF ELECTRIC LIGHTS AND MAIN CIRCUITS
AT THE
WATERVLIET ARSENAL, U.S.A.
7th Avenue
6th Avenue
5th Avenue
The Path
Canal
Broadway
Hudson River
N

PLATE I

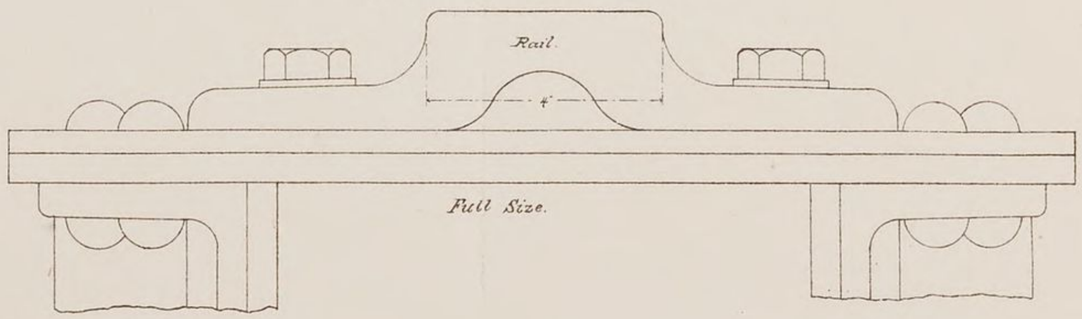

ARMY GUN FACTORY.
WATERVLIET ARSENAL U-S-A.
Scale.
SEA AND COAST DEPARTMENT.
1 Turning and boring lathe for 16-inch Guns.
2 Rifling machine for 12 to 16-inch Guns.
3 Turning & finishing lathes for 16-inch Guns.
4 Threading & slotting machine for 16-inch Guns
5 Jacket lathe for 16-inch Guns.
6 Threading & slotting machine.
7 Turning & boring lathe.
8 Turning & finishing lathe.
9 Rifling machine.
10 Jacket laths.
11 Horizontal boring milling & drilling machine.
12 Horizontal milling & drilling machine.
13 Slotting machine
14 Radial drills.
15 Upright drill.
16 Boring mills.
17 Hoop lathes.
18 Hoop boring machine.
19 Small lathes.
20 Shapers.
21 Gang drills.
22 Turret lathe.
23 Milling machines.
24 Planers.
25 Gear cutter.
26 Screw planer and shaper.
27 Profiling machine.
28 Grinding machine.
TOOL ROOM
29 Lathes.
30 Grindstones.
31 Universal grinding machines.
32 Tool grinders.
FIELD AND SIEGE DEPARTMENT
33 Gun lathes.
34 Lathes.
35 Upright drills.
36 Radial drill.
37 Slotter.
38 Gang drill
39 Shaper.
40 Universal grinding machine.
41 Milling machine.
42 Tool grinder.
43 Planers.
44 Grindstone.
45 Boring machine.
46 Rifling machine.
LOCOMOTIVE SHED.
COAL BINS.
OIL HOUSE.
400 HP.
250 HP.
SOUTH WING.
12 TO 16 INCH GUNS.
CENTRAL
SHRINKAGE
SECTION.
PIT.
NORTH WING.
8 TO 12 INCH GUNS.
WATER CLOSET.
GUNS AND FORGINGS.
STORE HOUSE.
Store
Room.
Turntable
FIELD AND SIEGE GUNS.

Cross Section through South Wing of Army Gun Factory showing location of crane-ways, etc. for 60 ton and 30 ton traveling cranes.

Scale.

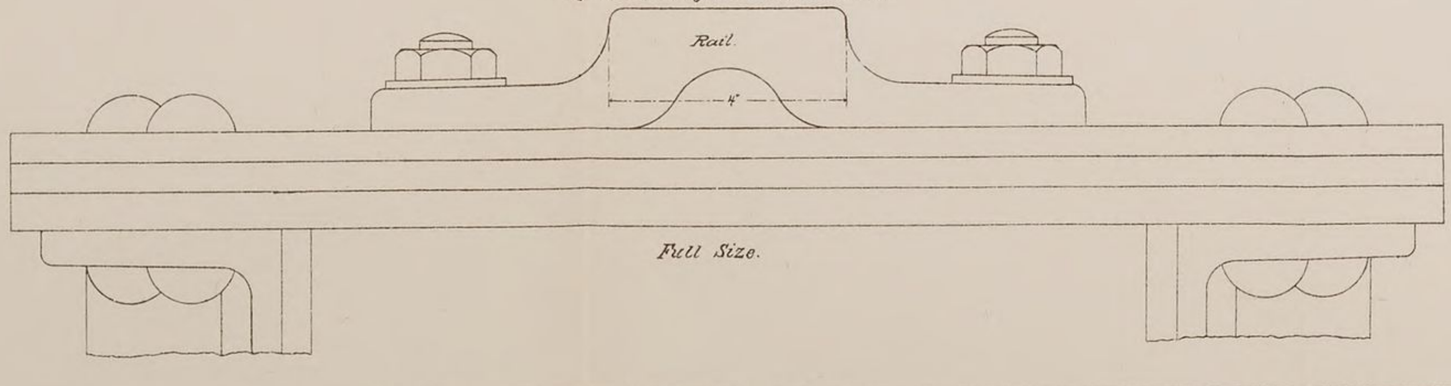


Top of run-ways for 30 ton crane.



Full Size.

Top of run-ways for 60 ton crane.



Full Size.

GUN FACTORY.

Watervliet Arsenal.

Electric lighting plant.

(South Wing).

Legend.

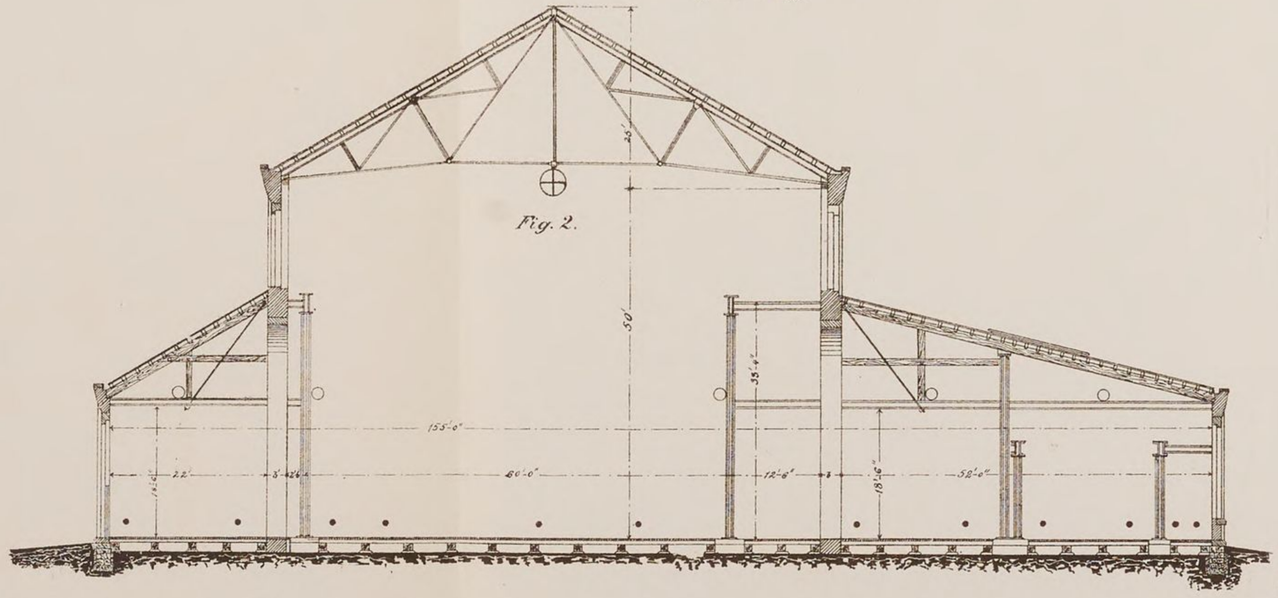
⊕ *Arc lights.*

○ *Incandescent lamps, 50 c.p., stationary.*

\+ " " , 16 c.p., " *in shaft tunnel.*

• " " , 16 c.p., *portable.*

Fig. 2.



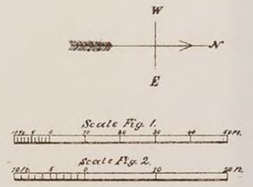
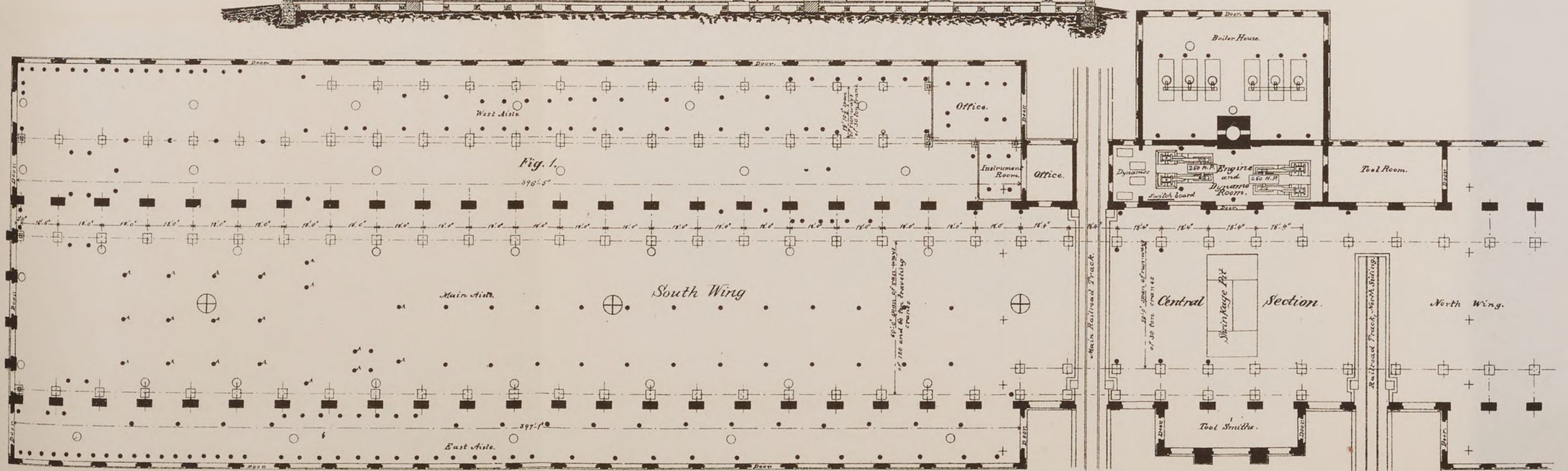
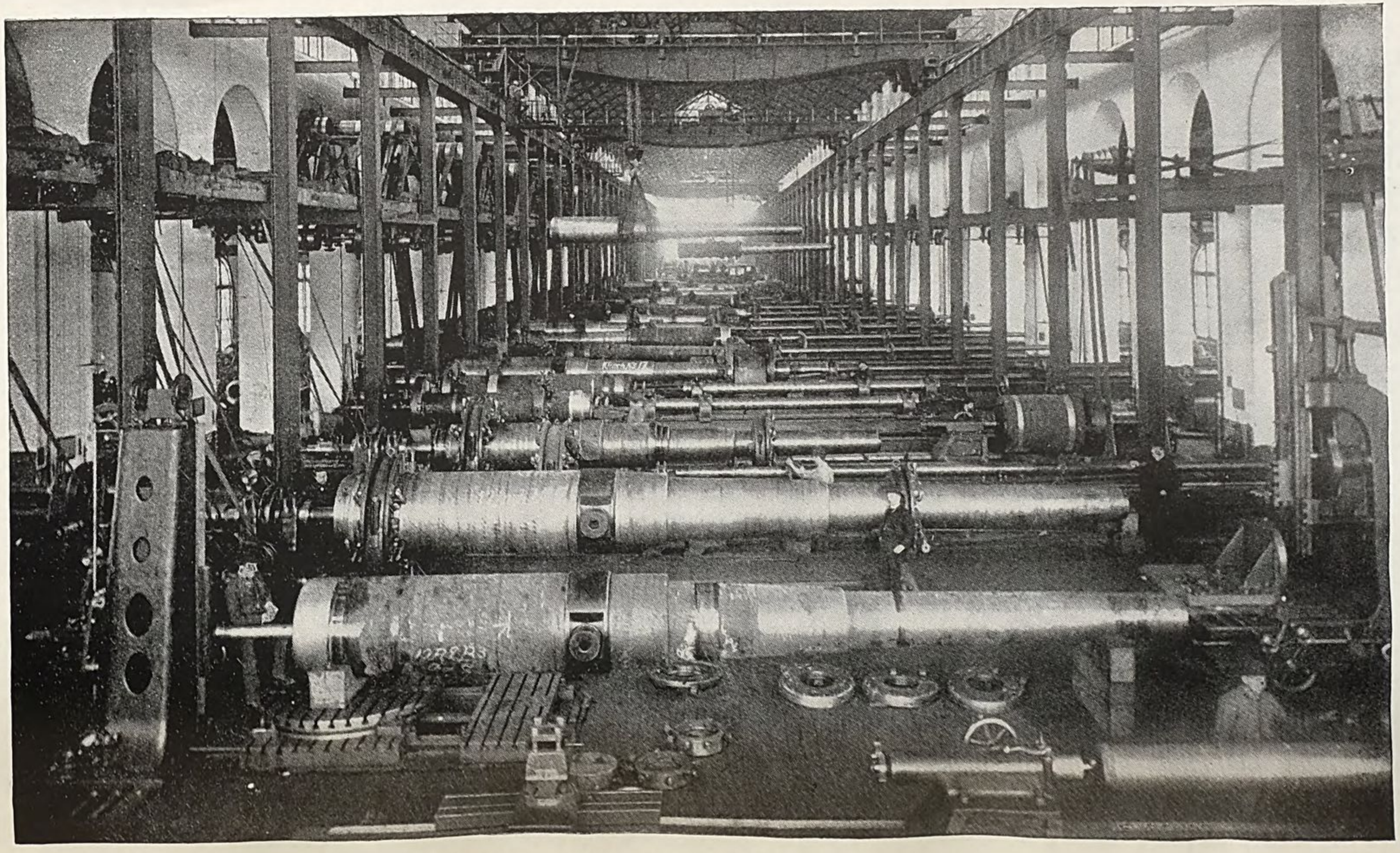
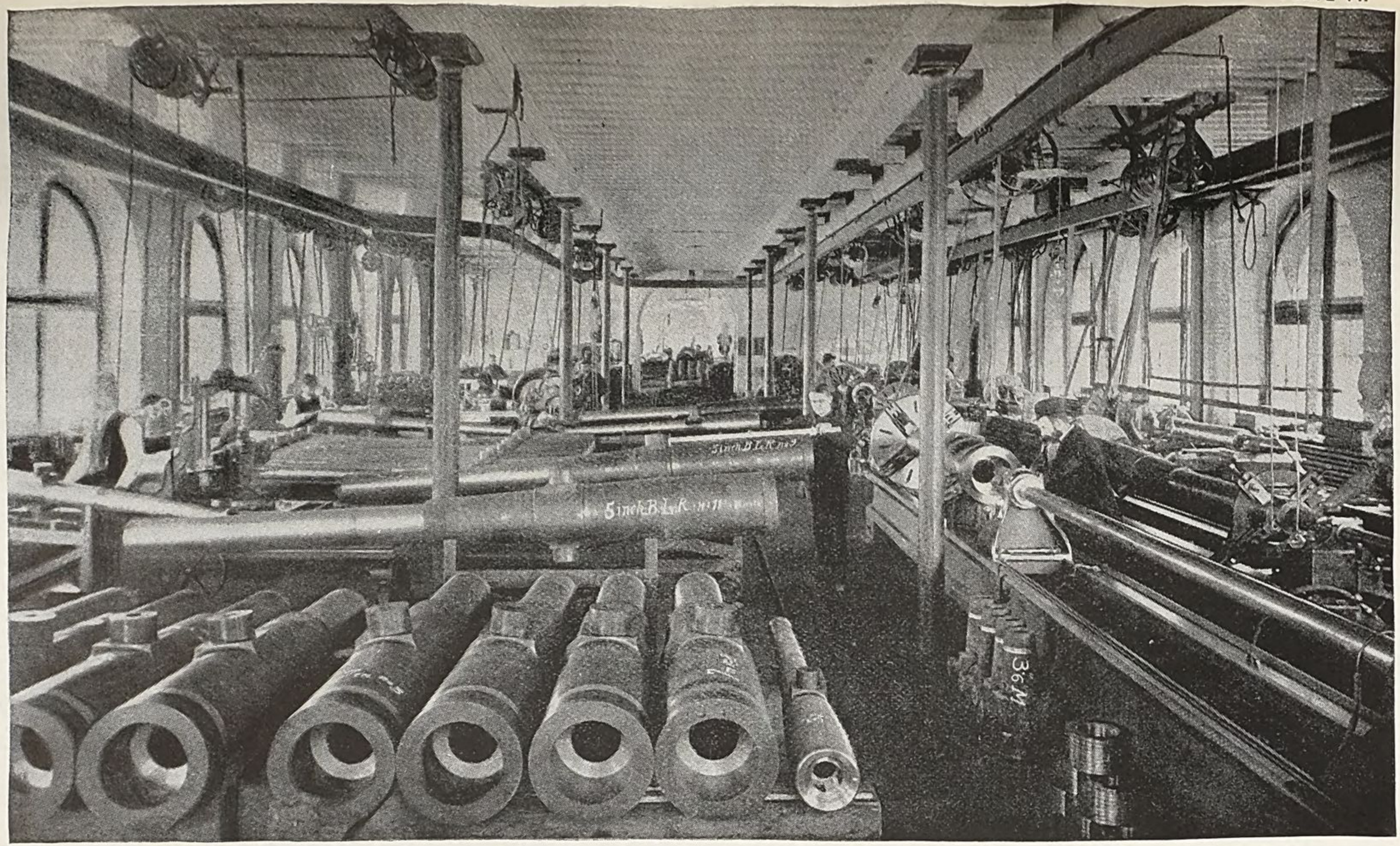


Fig. 1.

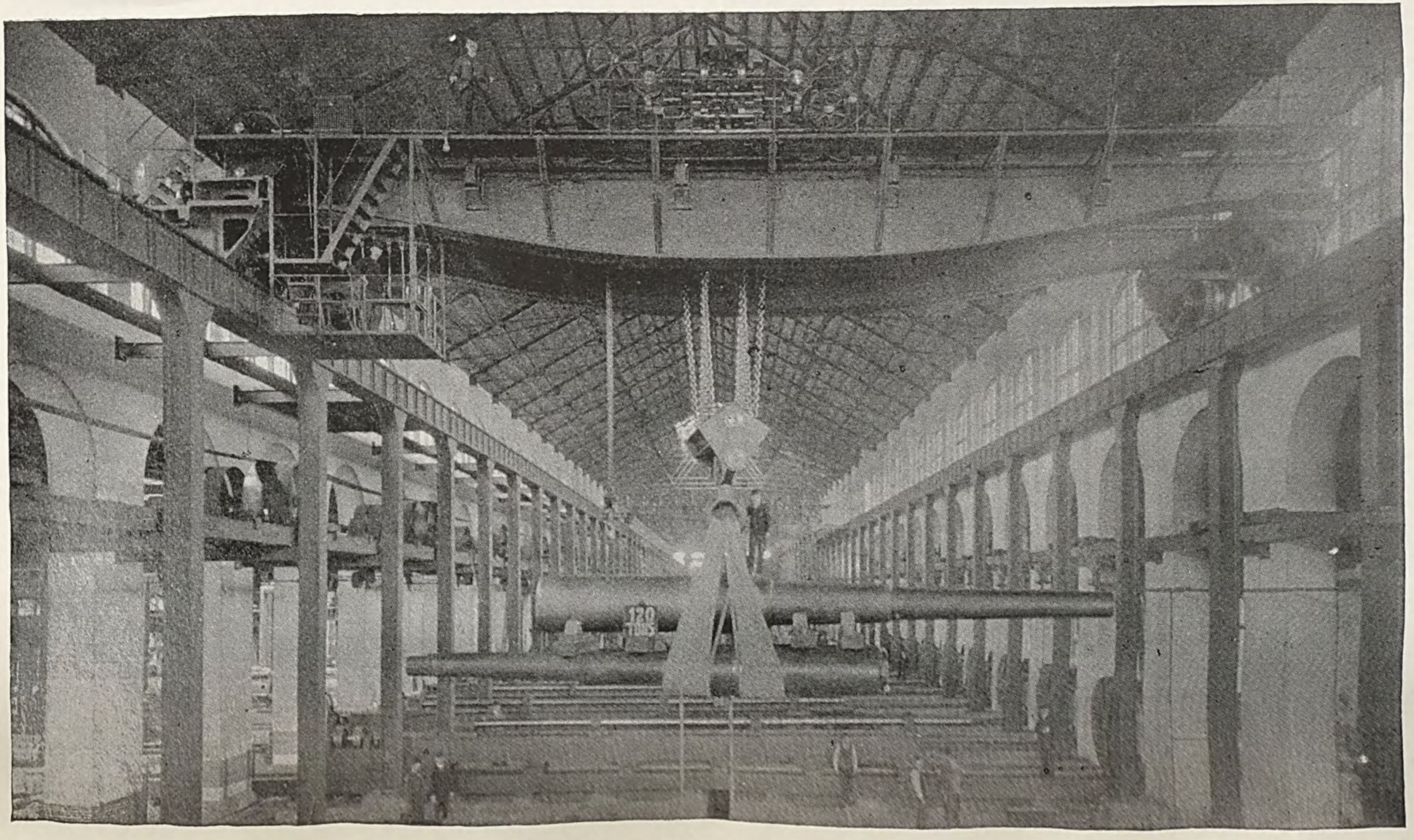




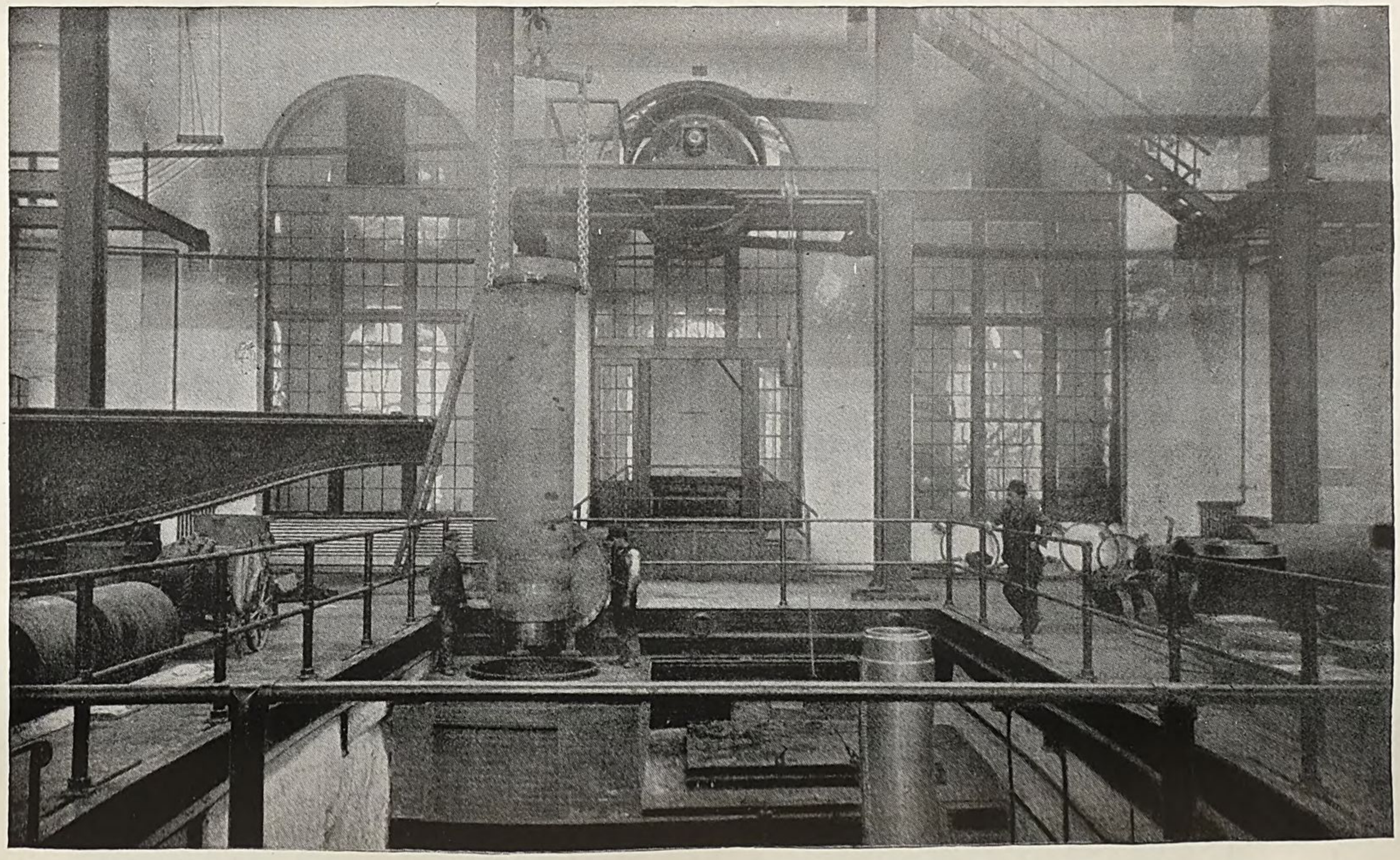
INTERIOR VIEW OF SEACOAST DEPARTMENT, WATERVLIET ARSENAL.



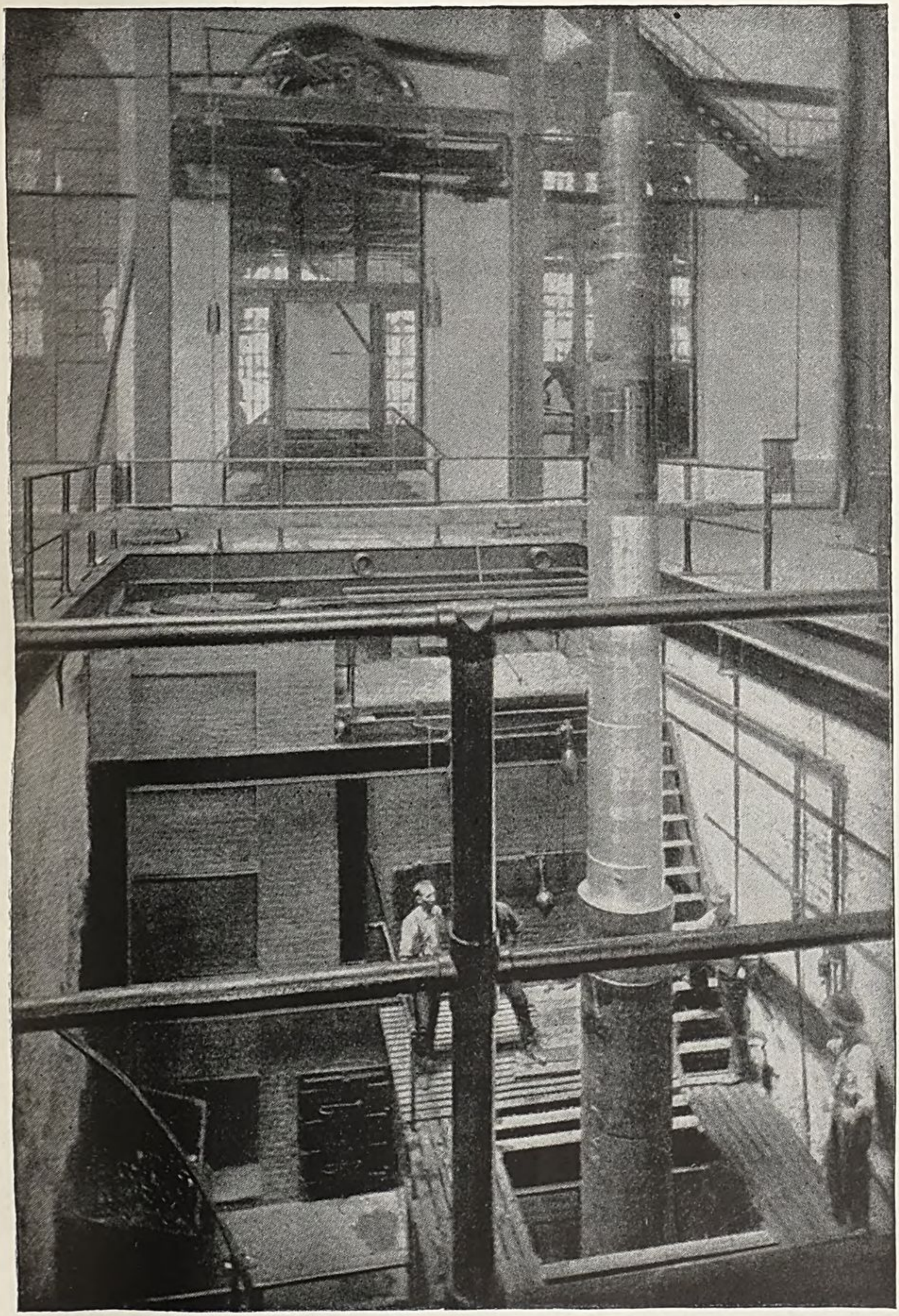
INTERIOR VIEW OF FIELD AND SIEGE DEPARTMENT, WATERVLIET ARSENAL.



TESTING 120-TON ELECTRIC TRAVELING CRANE, WATERVLIET ARSENAL.

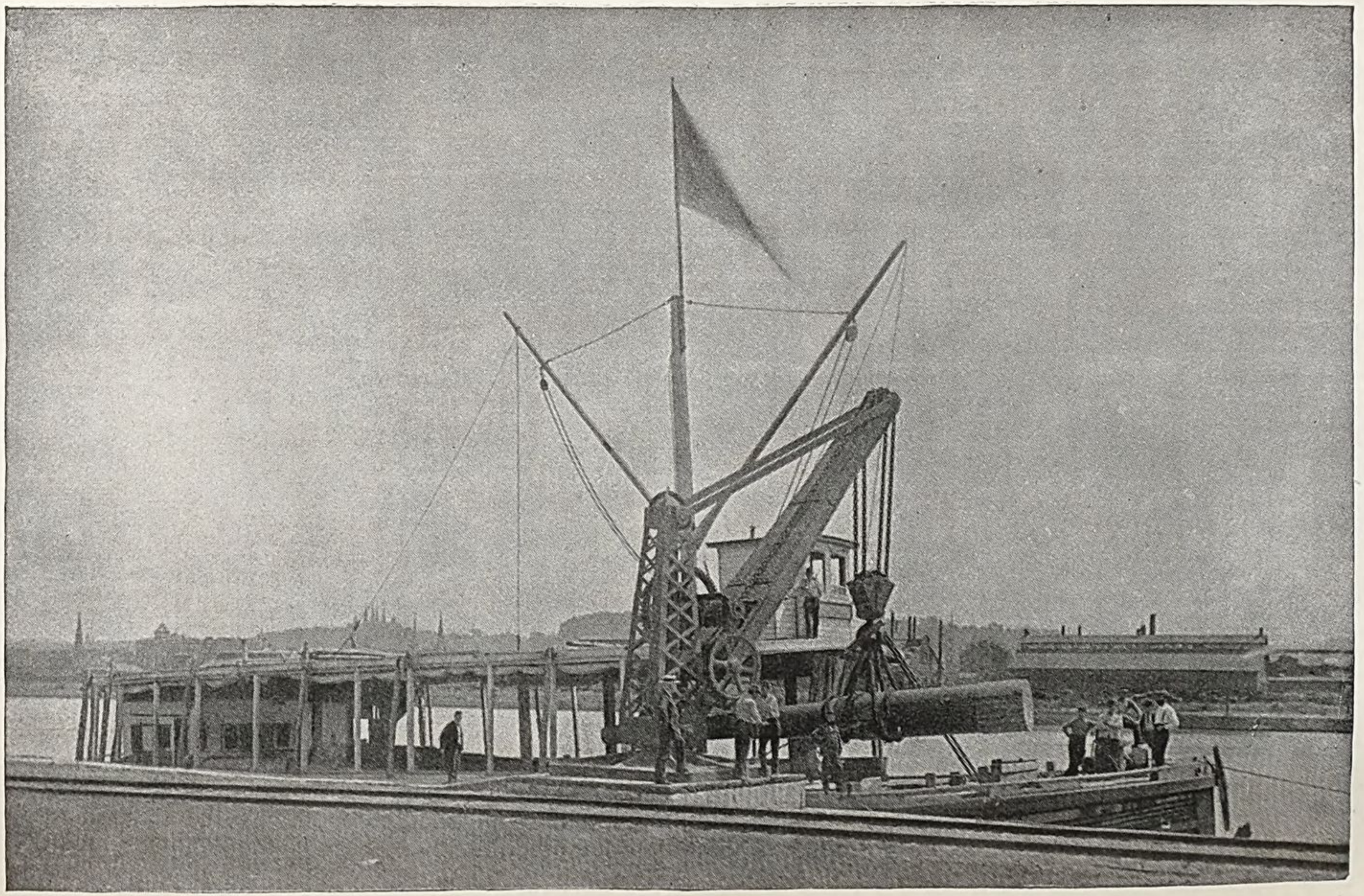


12-INCH JACKET SHRINKAGE OPERATION, WATERVLIET ARSENAL.



Appendix 21, 1893.

LOWERING GUN INTO PIT FOR HOOP SHRINKAGE, WATERVLIET ARSENAL.



SHIPPING 10-INCH GUNS, WATERVLIET ARSENAL.

APPENDIX 22.

REPORT ON MANUFACTURE OF 3.6-INCH B. L. FIELD-MORTAR CARRIAGES, PLATFORMS, AND IMPLEMENTS.

(1 plate.)

[See also Appendix 32, of 1892.]

WATERVLIET ARSENAL,
West Troy, N. Y., August 25, 1893.

SIR: Complying with your instructions, the following report, covering the manufacture of the 3.6-inch B. L. field-mortar carriages, platforms, and implements, is respectfully submitted.

The carriages were manufactured in accordance with the plans shown on tracing dated Ordnance Department, U. S. Army, July 7, 1891, revised July 22, 1892. The steel castings for the carriage frames and the elevating arcs were furnished by the Midvale Steel Company. The hooks, bolts, keys, cap squares, etc., required were fabricated at this arsenal, of low steel, wrought iron, or bronze, as specified. The work was all very simple machine work and calls for no special remark.

Considerable work was lost and the completion of the carriages was very much delayed on account of imperfect castings, both for the frames and the elevating arcs. The imperfections in the elevating arcs were blowholes; but in the frames not only were many blowholes found, especially about the trunnion beds, but the cheeks and transoms were in several cases so warped that it was impossible to finish the carriage to the dimensions required.

The bill of material, the weights, and the principal dimensions of the parts of the carriages are as follows:

Bill of material for one 3.6-inch field-mortar carriage.

BILL OF METAL.

Names of parts.	Number of pieces.	Thickness.	Width.	Length.	Total weight.	Remarks.
		Inches.	*Inches.*	*Inches.*	*Pounds.*	
Carriage frame	1	.....	.....	.....	287.0	Cast steel.
Elevating arc	1	.....	.....	.....	8.50	Cast steel.
Elevating-arc bolts	4	.75	1.25	3.25	3.35	
Elevating-arc guide pin	2	.875	Round.	1.5	.5	
Double hooks	2	2.0	1.0	5.0	5.6	Low steel.
Double-hook pins	2	.875	Round.	2.0	.67	Low steel.
Double-hook bracket	2	1.5	2.0	3.75	6.16	
Double-hook bracket pin	2	.875	Round.	2.0	.67	
Cap squares	2	1.25	2.75	15.0	28.85	Best Norway iron or equal.
Cap square keys	2	1.375	Round.	2.0	1.68	Low steel.
Cap-square-chain eye pin	2	.75	Round.	1.75	.42	Low steel.
Pintle fork	1	1.0	5.0	12.0	16.80	Best Norway iron or equal.
Pintle-fork bolt	1	1.125	Round.	3.0	.83	Low steel.
Elevating-arc jaws	2	1.25	2.0	8.0	11.25	Best Norway iron or equal.
Shaft for jaws	1	1.375	Round.	16.0	6.60	Low steel.
Lever for shaft	1	.....	.....	.....	1.75	Bronze.
Bushing for shaft	1	.....	.....	.....	1.0	Bronze.
Nut for shaft	1	.....	.....	.....	.50	Bronze.
Screw for bushing	1	.375	Round.	1.0	.03	Low steel.
Separator	1	.....	.....	11.0	1.2	Gas pipe.
Separator bolt and nut	1	1.25	Round.	14.0	4.77	Low steel.
Screws for pointing	2	.25	Round.	.5	.02	Brass.

The platforms and implements were manufactured in accordance with the drawings dated Ordnance Department, U. S. Army, July 10 and 13, 1891, both revised July 22, 1892, with the modification shown on drawing dated Watervliet Arsenal, March 8, 1893, amended March 27, 1893, except that the modification reduced the number of rivets for securing the cross pieces or "deck plank" to the side pieces from 20 to 16, and added 8 longer rivets for securing the wrought-iron straps in place; part of these rivets, however, performing a double function in also securing cross pieces to the side pieces. All the wood parts were made of oak.

The introduction of the wrought-iron side straps, embracing the side rails and bolted into cross pieces, was necessitated by the weakness of the mortised side rails. This weakness had been developed in the test of the experimental equipment for the mortars, and this method of strengthening was considered the best of the several suggested.

The bill of material, the weights, and the principal dimensions of the parts are as follows:

Bill of material for one 3.6-inch B. L. field-mortar platform.

BILL OF TIMBER.

Names of parts.	Number of pieces.	Thickness.	Width.	Length.	Total weight.	Remarks.
		Inches.	*Inches.*	*Inches.*	*Pounds.*	
Deck planks	11	5.5	3.5	33	194.1	Oak, rough dimensions.
Side rails	2	5.5	3.5	56	59.8	
Anchor block	1	4.5	3.5	37	16.2	
Anchor stake	1	4.5	4.5	49	27.6	
Pointing stakes	8	3.25	2.25	49	79.6	

BILL OF METAL.

Rivets for deck planks	16	.5	Round.	6.0	2.62	Best Norway iron or equal.
Rivets for side straps	8	.5	Round.	3.25	1.42	
Burrs for ½-inch rivets	24	.25	1.25 d.	Round.	2.04	Low steel.
Burrs, convex, ¾-inch bolt.	8	.25	1 d.	Round.	.19	
Nuts for ½-inch bolts	8	.....	.....	.....	1.0	Hexagonal, cold punched.
Nuts for ¾-inch bolts	3	.....	.....	.....	.75	
Scale socket	1	.....	.....	.....	1.0	Bronze.
Eye plates	2	.5	1.5	5.0	2.08	Best Norway iron or equal.
Stake loops	2	.5	Round.	16.0	1.75	
Bolts for eye plates	4	.5	Round.	4.75	1.03	
Straps for side rails	4	.125	1.5	20.0	4.17	
Bolts for pintle block	4	.5	Round.	4.375	1.0	
Bolts for anchor block	3	.75	Round.	7.25	2.67	
Pintle block	1	.....	.....	.....	4.5	Cast iron.
Anchor stake pins	2	1.25	Round.	8.0	5.50	Best Norway iron or equal.
Anchor stake collar	1	.625	1.125	14.0	2.73	
Washers for ¾-inch bolt	3	.5	2.0 d.	Round.	1.30	
Washers for ½-inch bolt	4	.25	1.5 d.	Round.	.48	

Very respectfully, your obedient servant,

F. E. HOBBS,
Captain, Ordnance Dept., U. S. Army.

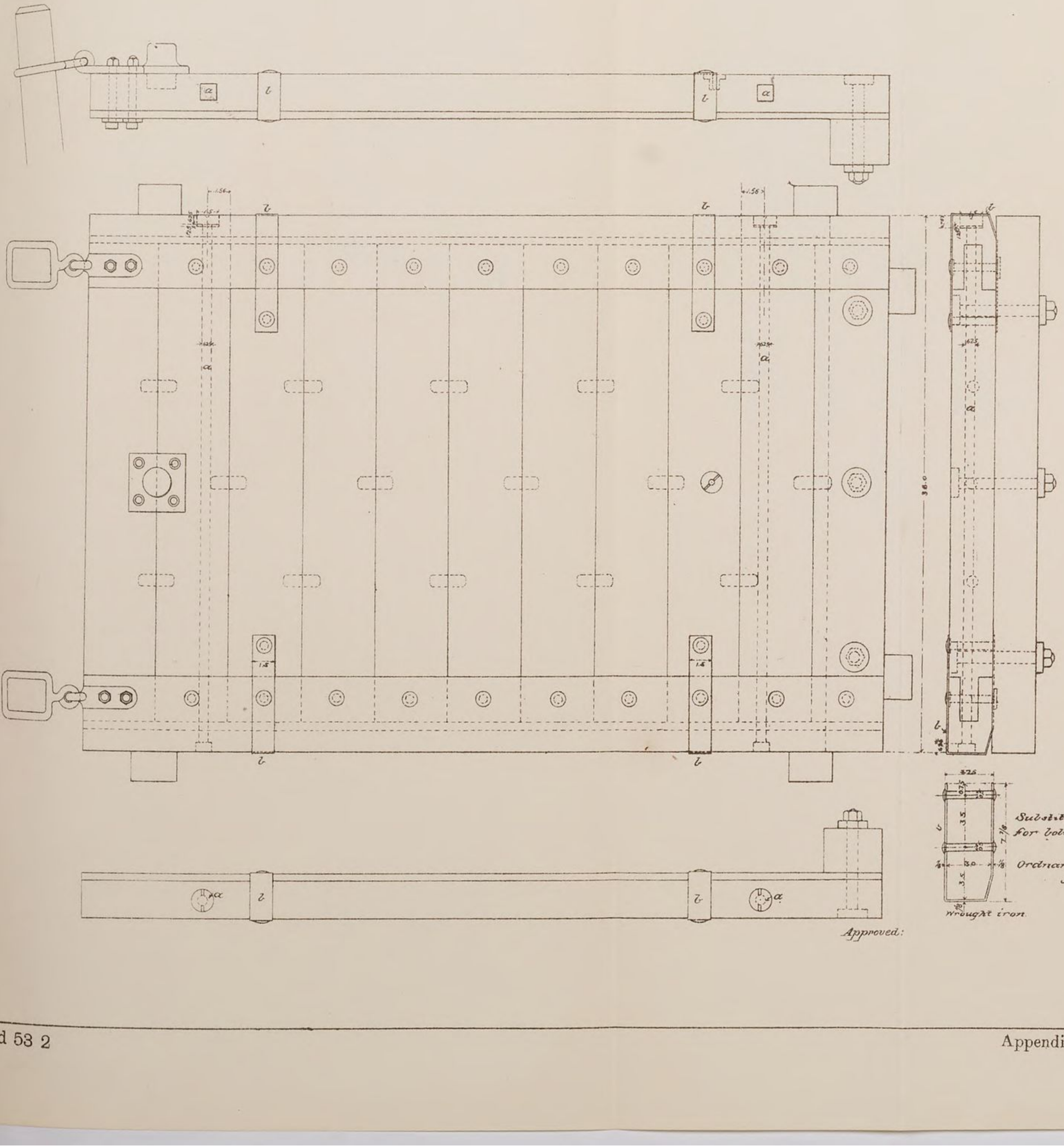
The COMMANDING OFFICER WATERVLIET ARSENAL.

(4772-'93.)

Watervliet Arsenal March 8th 1893.

PLATE I.

Amended Mar. 27. 1893.



Approved:

Ord 53 2

Appendix 22 1893.

APPENDIX 23.

SPECIFICATIONS FOR THE CONSTRUCTION OF A HIGHWAY BRIDGE OVER THE ERIE CANAL AT THE WATERVLIET ARSENAL, WEST TROY, N. Y.

The location of the bridge and its abutments and the details of its construction are shown in the accompanying blue prints (Pls. I to III).

The new bridge is to replace a wooden covered bridge, whose abutments will receive the former without change as to their form and dimensions. They are shown on Pl. I, as is also the road level of the bridge and the clearance line from the water level in the canal. Any repairs to the abutments which may be necessary, especially as regards repairs to the coping, will be made by the Ordnance Department. No part of the new bridge must project below the clearance line.

The contractor will take down the old wooden bridge at his own expense, and dispose of it as early as practicable, so as not to occupy and disfigure the grounds after the completion of the new bridge.

The new bridge can be assembled on the approaches. The western approach is especially adapted for this purpose, as its level roadway is within about 600 feet of the railroad track, where cars can be unloaded. The tracks at the arsenal connect with the Delaware and Hudson Canal Company's tracks.

False works or supports can be erected from the eastern abutment to the water's edge of the canal, and from the western abutment to within 15 feet of the water's edge. As the latter space forms the towpath, supports there or in the canal itself can be erected only with the consent of the State commissioner of public works, and permission for this purpose will have to be obtained by the contractor. He must also comply with the State and other laws, and is solely responsible for all penalties and all damages to life and limb that may occur owing to his negligence or that of his employés during the erection of the bridge and the removal of the old one. No claim for extra work shall be made unless before the performance of such extra work the commanding officer shall have first authorized, in writing, such extra work; nor unless, before the performance of such extra work the price to be paid therefor shall likewise first have been agreed upon, in a manner as required by law, between the Government and the contractor. All claims for extra work so ordered must be made to the commanding officer in writing before the final payment under the terms of the contract, otherwise they shall be considered as abandoned by the contractor. The contractor shall employ competent foremen and experienced mechanics and helpers, and shall immediately discharge, when required to do so by the commanding officer, any incompetent man or any one disposed to be disorderly.

The commanding officer will give, on demand, such interpretation, either verbally or by writing, as in his judgment the nature of the work may require, having particular care that any and all work done and material used for the work be such as hereinafter described. He shall also decide the amount of damages which may occur from any cause, and decide upon the fitness of all material used and work done.

All materials of every kind and description must be of the very best quality, and anything necessary to the completion of the work, as shown in the drawings, and as directed by these specifications, is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the commanding officer, to whom every facility is to be given by the contractor for inspecting the work as it progresses. The contractor is to furnish all necessary materials and labor, and is to provide all tools, derricks, hoists, scaffolding, planks, runs, and all mechanical appliances for properly prosecuting the work.

Dimensions figured on the drawings are to be followed in all cases in preference to scale measures, and the wording of the specifications takes precedence over both.

The bid will include the taking down of the old wooden bridge, which becomes the entire property of the contractor from the moment the operations of the erection of the new bridge begin.

Bidders will state the time for the completion of the whole work. If any delay occurs in the completion of the work beyond the date specified in the contract, a reduction shall be made in the price thereof of $10 for each and every day (excepting Sundays) after said date until the completion of the work.

Payment will be made after the complete erection and final acceptance of the bridge by the United States.

GENERAL DESCRIPTION.

The bridge will be a wrought-iron or steel-riveted lattice highway bridge with a wooden floor.

It will have an extreme length of 125 feet, and will be divided into ten panels, eight of 12 feet 3 inches each and two panels of 12 feet 3 inches by 14 feet 9 inches each. It will be 17 feet wide in the clear.

The bridge is intended for ordinary loads, the diagram of loads being given on Pl. I.

The drawings show the required dimensions of all parts, the number of rivets, and the details to be used. They also show the details and dimensions of parts of the wooden flooring, all of which must be sound, clear, and well-seasoned yellow pine. The floor planks will be 3 inches in thickness, the spiking strips 4 by 4 inches, and the wheel guards 4 by 6 inches. The spiking pieces must be securely bolted to the stringers, as called for in the drawings.

All ironwork is to receive one coat of good mineral paint in pure linseed oil before leaving the shop, and in addition all parts inaccessible to painting after erection shall receive a second coat before assembling.

After erection the bridge shall receive a final coat of light olive-green pure linseed oil paint.

All wrought iron and mild steel used in the construction of the bridge must be of domestic manufacture and of the following tensile strength and ductility on which the construction is based. The material is to have a tensile strength of not less than 50,000 pounds per square inch, an elastic limit of not less than 32,000 pounds per square inch, with 23

per cent elongation in 8 inches. Should wrought iron be used in any part of the work the tensile strength in pounds per square inch of test bars of tensile members shall be determined after the formula (all in inches):

$$52{,}000 - \frac{7{,}000 \times \text{area of original bar}}{\text{circumference of original bar.}}$$

The elongation must be 20 per centum.

All shaped iron must have a tensile strength in pounds per square inch of—

$$50{,}000 - \frac{7{,}000 \times \text{area of original bar}}{\text{circumference of original bar,}}$$

with an elongation of not less than 12 per centum.

All material and parts of the construction will be inspected by the inspector at the works of the contractor before shipment to the arsenal, and before any of it is painted, as to soundness and smoothness. He will make bending tests of the materials used in the construction. All built members must be true and free from twists, kinks, buckles, or open joints between component pieces. All abutting surfaces shall have proper contact.

The contractor will notify the commanding officer in due time of any inspection required under the above conditions.

All parts of the bridge will be finally inspected when erected in position, and this inspection will decide about the final acceptance of the work or any part of it by the United States.

The minimum weights and sizes of all metal parts are shown in the plans, and any materials which are not of the required weights or sizes will be rejected. All rivets must be of the best quality. The diameter of rivets must not be more than $\frac{1}{16}$ inch smaller than the hole they are to fill. Rivets to be heated to a uniform light-red heat before driving. No drift pins must be used. Holes to be reamed out till true. All rivets when driven must completely fill the holes and have full heads, well formed.

(4772–'93.)

APPENDIX 24.

SPECIFICATIONS FOR MACHINE TOOLS.

The following specifications comprise a series of machine tools required for the equipment of the south wing of Army Gun Factory at the Watervliet Arsenal, West Troy, N. Y. The machine tools are divided into classes, as follows:

Class A.—80-inch lathe for turning and boring hoops.
Class B.—76-inch lathe for turning and boring hoops.
Class C.—60-inch lathe for turning and boring hoops.
Class D.—72-inch vertical turning and boring mill, extra heavy, for hoops.
Class E.—16-inch lathes.
Class F.—18-inch slotter.
Class G.—Open-side combined planing and shaping machine, Pedrick & Ayer's.
Class H.—Universal milling machine, heavy, Pedrick & Ayer's.
Class I.—Horizontal boring, drilling, and milling machine, 9 by 6 feet.
Class K.—Automatic gear-cutter, 60-inch.

GENERAL SPECIFICATIONS FOR CLASSES A TO K, INCLUSIVE.

Bids will be considered for each class separately. Bidders to make two bids, one for the machine tools, delivered f. o. b., Watervliet Arsenal, West Troy, N. Y., and the other bid for delivery and erection in place, ready for operation in the new gun factory at the said arsenal. No belting is to be furnished. Bidders will furnish complete and exhaustive descriptions of their machines, accompanied by scale drawings, showing clearly all principal dimensions, and bids not accompanied by such drawings will not be considered. If desired, such drawings will be treated as confidential and returned to the bidder. Photographs may accompany such drawings, but photographs or cuts of machines only can not be considered sufficient to permit the merits of the tools to be determined. Exception as to drawings will be made for such tools as are designated by the name of the manufacturer in the specifications. Approximate weight of machines will be stated.

Bidders will state time of delivery.

For any delay in the completion of the machines beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price the sum of $20 for each and every day (excepting Sundays) after said date, until the completion of the contract.

Bids will be considered only for machine tools manufactured in the United States.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and

forming part thereof, the matter shall be at once referred to the Chief of Ordnance, U. S. Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

NOTE.—If any reliable manufacturer or bidder can show to the satisfaction of the Department that the machines upon which he bids are equal or superior to similar machines covered by these specifications, though differing therefrom in particulars which may be deemed unessential or immaterial as regards fitness for the performance of the particular work for which the said machines are intended, his bid will be received and duly considered in making the awards.

CLASS A.

Specifications for one 80-inch lathe for boring and turning hoops.

The lathe to swing 80 inches over the ways and not less than 64 inches over the carriage. Distance between centers to be 15 feet.

Driving cone to have five steps for 5-inch belt, ranging approximately from 15 to 27 inches diameter.

Lathe to be triple-geared, giving fifteen changes of speed.

No pinion to have less than 20 teeth, and back gear to be double and about of the following proportions:

Cone pinion, 24 teeth, Back gear, 84 teeth,	1-inch pitch, $2\frac{3}{4}$-inch face,	slow train.
Back gear pinion, 20 teeth, Main driving gear, 68 teeth,	$1\frac{1}{4}$-inch pitch, 4-inch face,	
Cone pinion, 50 teeth, Back gear, 60 teeth,	1-inch pitch, $2\frac{3}{4}$-inch face,	fast train.
Back-gear pinion, 20 teeth, Main driving gear, 68 teeth,	$1\frac{1}{4}$-inch pitch, 4-inch face,	

Pitch of gears to be not less than given in this schedule.

Back gear to be so arranged on shaft as to be made movable by screw along the shaft and clamped in position.

Cone shaft to be geared into face plate about as follows:

Face-plate gear, 138 teeth, $1\frac{3}{4}$-inch pitch, $5\frac{1}{2}$-inch face.

Face-plate pinion to be of steel, 17 teeth, $1\frac{3}{4}$-inch pitch, $5\frac{1}{2}$-inch face.

All pinions of less than 30 teeth must be made of sound steel casting or forging; all other gear of strong, close-grained cast-iron, having 25 per cent of cold-blast iron. All gearing must be accurately cut.

Diameter of cone and ratio of gearing may vary from the above, but power should remain same.

Main driving spindle.—To be of hard, close grained cast iron, with front bearing not less than 13 inches in diameter by 18 inches long; back bearing 9 inches diameter by 14 inches long; mixtures to contain 25 per cent of cold-blast iron.

Spindle to be fitted with steel bush in the front end to take the center, and with flange to bolt to face plate. Length of spindle in bearing to be about 5 feet.

Face plate.—To have a diameter of 79 inches, to be furnished with slots for clamping work, and fitted with four steel chuck jaws, set up by strong screws, so arranged as to clamp from the outside or the inside of hoops. Chuck jaws must be finished to one diameter in place, to have saw-tooth pattern face, and to be hardened. Face-plate gear to be made a separate casting and bolted to face plate. Spindle bearings

to be made in halves and capped, to have strong flanges on the ends, and to be made of close-grained hard iron, as specified for spindle.

Centers.—To be made of steel, hardened, and at least $3\frac{1}{2}$ inches in diameter, with points made to inclose an angle of 60 degrees.

Feeds.—All feeds to be arranged for steel. Feeds to be positive, driven by compound gearing, and ranging from $\frac{1}{40}$ inch for the finest to about $\frac{3}{8}$ inch for the coarsest. Reversing gear for feed to be placed at the end of the headstock or in the carriage, and change gears for screw cutting are to be provided to cut threads varying by $\frac{1}{8}$ inch and $\frac{1}{10}$ inch, and for the finest pitches of $\frac{1}{20}$ inch and $\frac{1}{16}$ inch and coarsest of 1 inch. Three changes of feed to be provided in headstock by clutch pin gears.

Lead screw.—To be of steel, $4\frac{1}{4}$ inches in diameter, $\frac{1}{2}$-inch pitch, and splined to drive-rack feed for turning. Lead screw nut must surround the screw entirely, and be operated by a cam, and not less than 10 inches long. Nut to be made of bronze.

Feed rack for carriage feed to be not less than 3-inch face and $1\frac{1}{8}$-inch pitch. To be of steel. All apron gears must be easily accessible for oiling.

Carriage.—To be at least 6 feet long and fitted to ways on the front and back of bed, and also bearing on the inner way used for the tail-stock guide. Fitted with one heavy compound rest.

Compound rest.—To have base not less than 20 inches wide by 35 inches long. To be provided with powerful cross feed, enabling rest to feed across entire width of face plate. Upper slide of compound rest to be provided with hand and power feed.

Wing rest.—To be placed on front wing of carriage for turning work the full swing of lathe.

Bed.—To be not less than 5 feet 4 inches in width over the top. To be fitted with three large ways, two for the carriage and the third one to guide head and tailstocks.

Bed must be so extended to the front that the line of strain when turning the full diameter of swing will fall inside the front way of bed. Cross girts to be box-girder form and not over 28 inches between centers. Depth of bed to be not less than 24 inches.

Tailstock.—To have bearing on bed not less than 46 inches long by 44 inches wide. Tailstock top to be arranged with convenient set-over and held down by four strong bolts, and, in addition, to have strong pawl dropping into ratchet on bed, giving a positive resistance to thrust. Tailstock spindle to be of steel forging $6\frac{1}{2}$ inches in diameter. Top of tailstock to be capped or otherwise arranged that tail spindle can be removed and a special boring bar put in its place. Tailstock to be provided with four rollers arranged to lift tailstock slightly off the bed and enable its easy and rapid moving on the bed.

Steady rest.—To hold the outer ends of hoops while being bored, a strong steady rest, of approved design, must be provided. Rest to have removable top and fitted with five steel jaws, adjustable by screws from behind, and faced with brass facings on the inner ends. Section of jaws to be not less than 8 by 4 inches. Three jaws to be placed in lower half of rest and two in upper half. Jaws to be accurately fitted to rest, and to be adjustable for diameters from 64 to 56 inches. Inner diameter of rest to be bored out in place for the reception of a reducing ring. This reducing ring is to have an opening of $56\frac{1}{2}$ inches in diameter. An extra set of jaws is to be provided. These are to be fitted into pockets of rest and reducing ring, and are to be adjustable for diameters from 56 to 48 inches.

Steady rest to have a bearing on bed not less than 20 inches long.

HOOP-BORING ATTACHMENTS.

A hoop-boring arrangement of the following general description is to be furnished with the lathe, and detailed drawings of it are to be submitted by the bidder.

Boring bar in tailstock.—The top of tailstock must be made removable, to be replaced by boring-bar bearing bolted to top of tailstock base. The boring bar to bore hoops ranging from 52 to 36 inches internal diameter and of a greatest length of 12 feet.

Boring bar.—To be of sound close-grained cast iron, not less than 15 inches in diameter, with core of 11½ inches diameter, and interior strongly ribbed. The bar is to extend through the hoop into a steadying bearing bolted to the front of face plate. Boring bar to be provided with suitable mechanism for quickly withdrawing it from the work, and to be accurately fitted to its bearing in the tailstock base, and to extend through to the feed bracket. The bearing is to be arranged to firmly clamp the bar while boring.

Boring head.—A traveling boring head, fitted to the bar, is to be provided and is to be fitted with rings of suitable sizes to bore all diameters from 52 to 36 inches. These rings must be solid on the front end, and must be provided with tool pockets, one inch square on the face, and with clamping straps for clamping the cutters. Boring head to be provided with feed nut engaging with feed screw placed in the bar.

Feed to boring head.—The feed to boring head to be driven by suitable mechanism, receiving motion from feed gearing in headstock, and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, viz, $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest. Feed gearing to be mounted in a special feed bracket, which latter is to be bolted to the top of bed, back of tailstock.

Steadying bearing.—The end of the boring bar next to the headstock is to be bored out and fitted with a bronze liner 9½ inches in diameter by 14 inches long. The liner is to have a sliding fit in a flange cast-iron hub with a bore of 9½ inches in diameter by 14 inches long, bolted to the front of face plate.

Taper attachment.—To turn the taper on the outside of hoops, a taper attachment of extra strength and great accuracy must be provided. This attachment must give tapers up to 1 inch to the foot in the diameter of the piece turned, and must be adjustable on the bed, and of length to turn a continuous taper 12 feet long.

The material and workmanship of this lathe must be first-class throughout. All gearing must be accurately cut. All shafts and feed screws to be of steel, and all bolts of steel or refined iron, and all nuts frequently used shall be casehardened.

All necessary countershafts, pulleys, wrenches, and other appliances to complete lathe ready for operation must be furnished.

Speed of countershaft to be such as to give cutting speeds of from 12 to 20 feet per minute.

CLASS B.

Specifications for one 76-inch lathe for boring and turning hoops.

The lathe is to swing 76 inches over the ways and not less than 52½ inches over the carriage. Distance between centers to be 16 feet.

Driving cone to have five steps for 5-inch belt, ranging approximately from 15 to 27 inches diameter.

Lathe to be triple geared, giving fifteen changes of speed.

No pinion to have less than 22 teeth, and back gear to be double and about of the following proportions:

Cone pinion, 24 teeth, Back-gear, 84 teeth,	1-inch pitch, $2\frac{3}{4}$-inch face,	slow train.
Back-gear pinion, 22 teeth, Main driving gear, 66 teeth,	$1\frac{1}{4}$-inch pitch, 4-inch face,	slow train.
Cone pinion, 50 teeth, Back gear, 60 teeth,	1-inch pitch, $2\frac{3}{4}$-inch face,	fast train.
Back-gear pinion, 22 teeth, Main driving gear, 66 teeth,	$1\frac{1}{4}$-inch pitch, 4-inch face,	fast train.

Pitch of gears to be not less than given in this schedule.

Back gear to be so arranged on shaft as to be made movable by screw along the shaft and clamped in position.

Cone shaft to be geared into face plate about as follows:

Face-plate gear, 112 teeth, $1\frac{3}{4}$-inch pitch, $5\frac{1}{2}$-inch face.

Face-plate pinion to be of steel, 17 teeth, $1\frac{3}{4}$-inch pitch, $5\frac{1}{2}$-inch face.

All pinions of less than 30 teeth must be made of sound steel casting or forging; all other gear of strong, close-grained cast iron, having 25 per cent of cold-blast iron. All gearing must be accurately cut.

Diameter of cone and ratio of gearing may vary from the above, but power should remain same.

Main driving spindle.—To be of hard, close-grained cast iron, with front bearing 11 to 12 inches in diameter by 16 inches long; back bearing 8 inches diameter by 12 inches long; mixture to contain 25 per cent of cold-blast iron.

Spindle to be fitted with steel bush in the front end to take the center, and to be driven into face plate. Length of spindle in bearing to be not less than 4 feet 6 inches.

Spindle bearings.—To be made in halves and capped, to have heavy flanges at ends, and to be made of hard, close-grained cast iron, the same as specified for spindle.

Face plate.—To be driven on and bolted to the spindle, and to have a diameter of 75 inches, to be provided with slots for clamping work, and with four adjustable steel jaws of large proportions, arranged to be set up by set-screws from the back. Chuck jaws to be arranged to be used either on the inner or outer side of hoops. They are to be turned to one diameter in place, hardened, and to have saw-tooth pattern faces. Face-plate gear to be made a separate casting and to be bolted to the face plate.

Centers.—To be made of steel, hardened, and at least $3\frac{1}{4}$ inches in diameter, with points made to inclose an angle of 60 degrees.

Feeds.—All feeds to be arranged for steel. Feeds to be positive, driven by compound gearing, and ranging from $\frac{1}{40}$ inch for the finest to about $\frac{3}{8}$ inch for the coarsest. Reversing gear for feed to be placed at the end of the headstock or in the carriage, and change gears for screw-cutting are to be provided to cut threads varying by $\frac{1}{8}$ inch and $\frac{1}{10}$ inch, and for the finest pitches of $\frac{1}{20}$ inch and $\frac{1}{16}$ inch and coarsest of 1 inch. Three changes of feed to be provided in headstock by clutch pin gears.

Lead screws.—To be of steel, 4 inches in diameter, $\frac{1}{2}$-inch pitch, and splined to drive rack feed for turning. Lead-screw nut must surround the screw entirely, and be operated by a cam, and not less than 10 inches long. Nut to be made of bronze.

Feed rack for carriage feed to be not less than 3-inch face and $1\frac{1}{8}$-inch pitch. To be of steel. All apron gears must be easily accessible for oiling.

Carriage.—To be at least 6 feet long, and fitted to ways on the front and back of bed, and also bearing on the inner way used for the tail stock guide. Fitted with one heavy compound rest.

Compound rest.—To have base not less than 20 inches wide by 30 inches long. To be provided with powerful cross-feed, enabling rest to feed across entire width of face plate. Upper slide of compound rest to be provided with hand and power feed.

Wing rest.—To be placed on front wing of carriage for turning work the full swing of lathe.

Bed.—To be not less than 5 feet 4 inches in width over the top. To be fitted with three large ways, two for the carriage and the third one to guide head and tail stocks.

Bed must be so extended to the front that the line of strain when turning the full diameter of swing will fall inside the front way of bed. Cross girts to be box-girder form and not over 28 inches between centers. Depth of bed to be not less than 24 inches.

Tailstock.—To have bearing on bed not less than 43 inches long by 42 inches wide. Tailstock top to be arranged with convenient set-over, and held down by four strong bolts, and in addition to have strong pawl dropping into ratchet on bed, giving a positive resistance to thrust. Tailstock spindle to be of steel forging $6\frac{1}{2}$ inches diameter. Top of tailstock to be capped or otherwise arranged that tail spindle can be removed and special boring bar put in its place. Tailstock to be provided with four rollers arranged to lift tailstock slightly off the bed and enable its easy and rapid moving on the bed.

Steady rest.—To hold the outer ends of hoops while being bored, a strong steady rest, of approved design, must be provided. Rest to have removable top and fitted with five steel jaws, adjustable by screws from behind and faced with brass facings on the inner ends. Section of jaws to be not less than 8 by 4 inches. Three jaws to be placed in lower half of rest and two in upper half. Jaws to be accurately fitted to rest, and to be adjustable for diameters from 50 to 44 inches. Inner diameter of rest to be bored out in place for the reception of a reducing ring. This reducing ring is to have an opening of $44\frac{1}{2}$ inches in diameter. An extra set of jaws is to be provided. These are to be fitted into pockets of rest and reducing ring, and are to be adjustable for diameters from 44 to 36 inches. Steady rest to have a bearing on bed not less than 20 inches long.

HOOP-BORING ATTACHMENTS.

A hoop-boring arrangement of the following general description is to be furnished with the lathe, and detailed drawings of it are to be submitted by the bidder:

Boring bar in tailstock.—The top of tailstock must be made removable, to be replaced by boring bar bearing bolted to top of tailstock base. The boring bar to bore hoops ranging from 42 to 26 inches internal diameter and of a greatest length of 12 feet.

Boring bar.—To be of sound, close-grained cast iron, not less than 15 inches in diameter, with a core of $11\frac{1}{2}$ inches diameter, and interior strongly ribbed. The bar is to extend through the hoop into a steadying bearing bolted to the front of face plate. Boring bar to be provided with suitable mechanism for quickly withdrawing it from the work, and to be accurately fitted to its bearing in the tailstock base, and to extend through to the feed bracket. The bearing is to be arranged to firmly clamp the bar while boring.

Boring head.—A traveling boring head, fitted to the bar, is to be provided, and is to be fitted with rings of suitable sizes to bore all diameters from 42 to 26 inches. These rings must be solid on the front end, and must be provided with tool pockets, one inch square, on the face, and with clamping straps for clamping the cutters. Boring head to be provided with feed nut engaging with feed screw placed in the bar.

Feed to boring head.—The feed to boring head to be driven by suitable mechanism, receiving motion from feed gearing in headstock, and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, viz: $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest. Feed gear to be mounted on a special feed bracket, which latter is to be bolted to the top of bed back of tailstock.

Steadying bearing.—The end of the boring bar, next to the headstock, is to be bored out and fitted with a bronze liner 9½ inches in diameter by 14 inches long. The liner is to have a sliding fit in a flanged cast-iron hub with a bore of 9½ inches in diameter by 14 inches long, bolted to the front of face plate.

Taper attachment.—To turn the taper on the outside of hoops, a taper attachment of extra strength and great accuracy must be provided. This attachment must give tapers up to 1 inch to the foot in the diameter of the piece turned, and must be adjustable on the bed, and of length to turn a continuous taper 12 feet long.

The material and workmanship of this lathe must be first class throughout. All gearing must be accurately cut. All shafts and feed screws to be of steel, and all bolts of steel or refined iron, and all nuts frequently used shall be casehardened.

All necessary countershafts, pulleys, wrenches, and other appliances to complete lathe ready for operation must be furnished.

Speed of countershaft to be such as to give cutting speeds of from 12 to 20 feet per minute.

CLASS C.

Specifications for one 60-inch lathe for turning and boring hoops.

This lathe is to swing 60 inches over the ways and 48 inches over the carriage and is to take 15 feet between centers.

Driving cone.—To have five steps for 4½-inch belt, diameter of smallest step to be not less than 15 inches. Lathe to be triple geared, giving 15 changes of speed.

Back gear.—To be double, of approximately the following proportions:

Cone pinion, 24 teeth, Back gear, 84 teeth,	¾-inch pitch, 3-inch face,	slow train.
Back gear pinion, 20 teeth, Driving gear, 70 teeth,	1-inch pitch, 4-inch face,	
Cone pinion, 60 teeth, Back gear, 60 teeth,	¾-inch pitch, 3-inch face,	fast train.

Pitch of gears to be not less than given in this schedule. Back gears to be movable by screws along their shaft and clamped in position.

Face-plate gear to have about 120 teeth, 1½-inch pitch, 4½-inch face; face-plate pinion to be of forged steel.

Diameter of cone and ratio of gearing may vary from the above, but power should be the same.

Spindle.—To be made of close-grained, hard cast iron, containing at least 25 per cent of cold-blast iron. Front bearing 10 inches diameter

by 14 inches long, back bearing 7 inches diameter by 10 inches long. Spindle to be driven into face plate and provided with steel bush for center. Length of spindle in bearings to be not less than 54 inches.

Spindle bearings.—To be made in halves and capped. To have heavy flanges on the ends, and made of hard close-grained cast iron, same as specified for spindle.

Face plate.—To be driven on and bolted to the spindle. To be 60 inches diameter. To have slots for clamping work, and provided with four adjustable steel jaws of large proportions, arranged to be set up by set screws from the back. Chuck jaws to be arranged to be used either on the inner or outer side of hoops. They are to be turned to one diameter in place and hardened, and to have diamond pattern face. Face-plate gear to be made a separate casting and bolted to face plate.

Centers.—To be made of steel, 3 inches diameter, hardened, and pointed to inclose an angle of 60 degrees.

Feeds.—To be positive, driven by compound gearing from headstock. Feed gears to give range of feed from $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest. Three changes of feed to be provided in headstock by clutch-pin gears.

Change gears for screw-cutting must be provided for changing pitches by $\frac{1}{10}$ and $\frac{1}{8}$ inch, and for cutting screw threads ranging from $\frac{1}{20}$ to $\frac{1}{16}$ inch for the finest to 1 inch for the coarsest.

Material for gearing.—All pinions of less than 30 teeth to be made of sound steel casting or forging. All other gears to be of close-grained cast iron, containing 25 per cent of cold blast iron. All gearing throughout to be accurately cut.

Lead screws.—To be of steel 3 inches diameter and $\frac{1}{2}$ inch pitch; to be fitted with lead-screw nut, operated by cam, and not less than 9 inches long, and to be made of bronze.

Feed rack, for carriage feed, to be not less than 3 inches face and $\frac{3}{4}$ inch pitch. To be of steel.

Apron gears and bearings for same must be easily accessible for oiling, and apron arranged with reversing gear for the carriage feed, and mechanism must be provided for preventing rack feed and lead-screw nut from being thrown into gear at the same time.

Carriage.—To be not less than 5 feet long, and fitted to ways in the front and back of bed, and bearing on the inner way used for the tailstock guide. Carriage to be fitted with one heavy compound tool rest.

Compound rest.—To have base not less than 18 inches wide by 24 inches long. To be provided with power cross feed for heavy work. Power feed to be provided for the upper slide of rest.

Wing rest.—To be placed on front wing of carriage, for turning work the full swing of lathe.

Bed.—To be not less than 48 inches wide and fitted with three ways, two for the carriage and one to guide the tailstock. Bed must be well extended to the front to give support to the carriage, so that the line of strain, when turning the full diameter of swing, will fall inside the front way of bed. Cross girts must be of box-girder form and 24 inches between centers. Depth of bed to be not less than 20 inches.

Tailstock.—To have a bearing on the bed 40 inches long by about 32 inches wide. Tailstock to be provided with convenient set-over and held down by four strong bolts. In addition tailstock base is to be provided with a strong pawl, dropping into ratchet in bed, giving a positive resistance to thrust. Tail spindle to be of steel, $6\frac{1}{2}$ inches diameter. Top of tailstock to be capped, or otherwise arranged so that tail spindle can be removed and boring bar put in its place. Tailstock

to be provided with four rollers, arranged to lift tailstock slightly off the bed and enable easy and rapid movement along the bed.

Steady rest.—To hold the outer ends of hoops while being bored, a strong steady rest, of approved design, must be provided. Rest to have removable top and to be fitted with five steel jaws, adjustable by screws, and faced with bronze caps on the inner ends. Section of jaws to be 6 by 3½ inches. Three jaws to be placed in the lower half and two in the upper half of steady rest, and to be accurately fitted to their pockets. Jaws to be adjustable for diameters from 42 to 34 inches. Inner diameter of rest to be bored out in place for the reception of a reducing ring. This reducing ring is to have an opening of 34½ inches in diameter. An extra set of jaws is to be provided. These are to be fitted into pockets of rest and reducing ring, and are to be adjustable for diameters from 34 to 26 inches. Steady rest to have a bearing on bed of not less than 15 inches in length.

HOOP BORING ATTACHMENTS.

A hoop boring arrangement of the following general description is to be furnished with each lathe, and detailed drawings of it are to be submitted by the bidder.

Boring bar in tailstock.—The top of tailstock must be made removable, to be replaced by boring bar bearing bolted to top of tailstock base. The boring bar to bore hoops ranging from 26 to 36 inches internal diameter, and having a greatest length of 12 feet.

Boring bar.—To be of sound close-grained cast iron, not less than 15 inches in diameter, with a core of 11½ inches in diameter, and interior strongly ribbed. The bar is to extend through the hoop into a steadying bearing bolted to the front of face plate. Boring bar to be provided with suitable mechanism for quickly withdrawing it from the work, and to be accurately fitted to its bearing in the tailstock base and to extend through to the feed bracket. The bearing is to be arranged to firmly clamp the bar while boring.

Boring head.—A traveling boring head, fitted to the bar, is to be provided and is to be fitted with rings of suitable sizes to bore all diameters from 36 to 26 inches. These rings must be solid on the front end, and must be provided with tool pockets, one inch square, on the face, and with clamping straps for clamping the cutters. Boring head to be provided with feed nut engaging with feed screw placed in the bar.

Feed to boring head.—The feed to boring head to be driven by suitable mechanism, receiving motion from feed gearing in headstock, and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, from $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest. Feed gear to be mounted on a special feed bracket, which latter is to be bolted to the top of bed back of tailstock.

Steadying bearing.—The end of the boring bar, next to the headstock, is to be bored out and fitted with a bronze liner 9½ inches in diameter by 14 inches long. The liner is to have a sliding fit in a flanged cast iron hub having a bore of 9½ inches diameter by 14 inches long, bolted to the front of face plate.

Taper attachment.—To turn the taper on the outside of hoops, a taper attachment of extra strength and great accuracy must be provided. This attachment must give a range of tapers from 0 to 1 inch to the foot in the diameter of piece turned, and must be adjustable along the bed, and of length sufficient to turn a continuous taper 12 feet long.

All necessary countershafts, pulleys, wrenches, and other equipments to complete lathe ready for running must be furnished.

Countershafts' speed to be arranged for a cutting speed of from 12 to 20 feet per minute.

The material and workmanship of this lathe must be first class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be case-hardened.

CLASS D.

Specifications for one 72-inch vertical boring mill (extra heavy), for boring and turning hoops 48 inches deep; to turn 73 inches diameter and 48 inches high under tool-holders.

This machine to consist of bed not less than 20 inches deep, with table supported on circular bearing near outer circumference. Table to be driven on and bolted to a long spindle with split conical sleeve at upper end and step bearing at lower end. Step-bearing to be joined to bed by a heavy cast-iron truncated cone reaching down from the bottom of bed.

Housings.—To be of box form, with heavy front post at least 8 inches on the face. Housings to be bolted to bed by six bolts $1\frac{3}{4}$ inches diameter, and to reach down the full depth of bed. Top of housings to be joined by a top brace at least 22 inches deep.

Cross rail.—To be of box form, with arched back, completely closed. Depth of housing on face to be not less than 23 inches. Depth from face to back in center to be not less than 18 inches.

Cross rail to be fitted to front of housings, and accurately scraped to give full and perfect bearing on housing faces.

Boring heads.—Two boring heads, each fitted with independent cross-feed screw and down-feed rod to be accurately fitted to cross rail; each head to consist of saddle 26 inches wide, swing arranged for set-over for turning tapers. Set-over to be operated and controlled by worm gearing on the upper circular arc of saddle. Length of swing to be not less than 48 inches, and to have capped bearing at upper and lower ends for boring bar.

Boring bars.—To be of open-hearth steel, containing one-half per cent of carbon, to be octagon in section; section to be equal to area of $8\frac{1}{2}$-inch circle. Lower ends of bars to be fitted with removable tool-holders of forged steel, so arranged that tools can be set in vertical or horizontal positions on either side of bar. Vertical travel of bars to be 50 inches.

Feeds.—Each head to be provided with cross feed for saddle and vertical feed for bar. Feeds to be reversible and independent for each head.

Right-hand head to be fitted with opening nut on feed screw, and provided with rack pinion for rapid movement on the cross rail.

Feed to be driven by friction disk, and quickly adjustable to any degree from $\frac{1}{40}$ to $\frac{1}{4}$ inch.

Counterweight.—Bars to be counterbalanced by one weight common to both bars. Chain and sheaves for counterweight to be arranged to always pull in a direction parallel with the axis of bar.

Table.—To have diameter of 70 inches, and to be not less than 5 inches deep on outer rim.

To be provided with T-slots for holding work, and, in addition, to have four hardened steel chuck jaws, with diamond-point faces, adjusta-

ble to any diameter, and arranged for inside or outside chucking, and to be readily removable, leaving the table clear for other work.

Spindle.—To be 11 inches diameter at upper end, with upper bearing not less than 11 by 16 inches long, fitted in split conical bush for taking up wear. Lower spindle bearing to be not less than 6 inches diameter by 10 inches long. Length of spindle under table to be not less than 50 inches. Spindle and bushes to be made of strong close-grained cast iron containing 25 per cent of cold-blast iron. Lower spindle step to be provided with wedge for raising table off the outer bearing.

Driving gear.—Table is to be driven by cone pulley placed in the left-hand side of bed and transmitting motion to table by means of horizontal shaft, bevel gears, vertical shaft, and circular gear and pinion under table.

Table rack gear.—To have about 120 teeth and not less than $1\frac{3}{8}$-inch pitch and 6-inch face. To be accurately cut from the solid. Gear to be bolted to the bottom of table.

Driving pinion.—To be of forged steel and to have not less than 20 teeth, $1\frac{3}{8}$-inch pitch and 6-inch face.

Driving cone.—To have six steps for 4-inch belt, ranging about from 12 to 26 inches diameter. Cone to be back geared approximately as follows:

Cone pinion, 25 teeth, $\frac{3}{4}$-inch pitch.
Back gear, 100 teeth, $\frac{3}{4}$-inch pitch.
Back-gear pinion, 20 teeth, 1-inch pitch.
Cone spur, 80 teeth, 1-inch pitch.

Bevel gears to have about 25 and 35 teeth, respectively, and not less than $1\frac{3}{4}$-inch pitch and 5-inch face, giving 12 changes of speed.

Ratio of cone to table to be about 130 revolutions of cone to one revolution of table.

SPECIAL BORING BAR AND STEADY REST.

For boring hoops having a height of 48 inches a special boring bar and steady rest are to be provided.

The boring bar to be made of open-hearth steel, and not less than 9 inches in diameter. Lower end of bar to be fitted to step in the table. Step to be provided with conical adjustment to take up wear. Upper end of bar to be held in a saddle fitted to the front of cross rail. Bar to be counterweighted and provided with rack and pinion for quickly withdrawing from the work.

A traveling boring head to be provided and accurately fitted to bar. Head to be arranged for four adjustable cutters, and to be furnished with rings suitable for boring all diameters ranging from 32 to 40 inches. Boring head to be provided with feed nut engaging with feed screw inserted in boring bar.

The feed for the boring head is to be driven by suitable mechanism, transmitting motion from the feed works of the mill. Range of feeds to be from $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest.

For steadying the upper end of hoops a strong and substantial steady rest must be provided. Steady rest to be arranged to clear the work when putting the same on the mill. To be fitted with five steel jaws adjustable by screws and faced with brass facings on the inner ends. Section of jaws to be not less than $4\frac{1}{2}$ by $2\frac{1}{4}$ inches. Jaws to be adjustable for diameters ranging from 48 to 38 inches.

Material.—Driving shafts to be of open-hearth steel containing $\frac{1}{2}$ per cent of carbon. Shafts to run in bronze bushes containing 90 per cent of copper and 10 per cent tin. All other shafts and all feed screws to

be of good machinery steel. All bolts to be of refined iron, and all nuts frequently used to be casehardened.

Gearing.—All the gearing to be made of strong, close-grained iron, containing not less than 25 per cent of cold-blast iron, unless otherwise specified. All pinions having less than 30 teeth to be of forged steel.

Workmanship and material to be first-class throughout.

All working parts to be accurately fitted, and all bearing surfaces to be accurately scraped to perfect bearings.

All countershafts, hangers, pulleys, wrenches, and all other appliances to complete machine ready for operation are to be furnished with mill. Foundation plans to be furnished.

CLASS E.

Specifications for two 16-inch lathes (as built by the Pratt and Whitney Company or equal).

Lathe to swing 16 inches over the ways and $7\frac{1}{2}$ inches over the carriage, and to take 4 feet 6 inches between the centers.

Driving cone.—To have four steps for $2\frac{1}{2}$-inch belt, smallest step to be not less than 5 inches diameter and geared to spindle in ratio of about 10 to 1, giving eight changes of speed.

Spindle.—To be made of open-hearth steel. Front bearing to be $2\frac{1}{4}$ inches diameter by about $4\frac{1}{2}$ inches long. Back bearing to be about 2 inches diameter and $3\frac{1}{2}$ inches long. Length of spindle in bearings to be about 24 inches. Hole through full length of spindle $\frac{3}{4}$ inch.

Spindle-bearing.—To be made of hard bronze, containing 85 per cent of copper and 15 per cent of tin. Bearings to have heavy flanges at the ends and to be carefully scraped to fit spindle.

Face plate.—To be screwed to front end of spindle.

Centers.—To be of good steel, $\frac{15}{16}$ inch diameter, hardened, and pointed to inclose an angle of 60 degrees.

Feeds.—To be by gearing.

Compound gearing.—To be provided for cutting screw threads varying from 3 to 48 threads to the inch.

Material for gearing.—All gearing, of whatever description, is to be accurately cut and made of steel or strong, close-grained iron.

Lead screw.—To be of steel $1\frac{1}{16}$ inches in diameter, $\frac{3}{16}$-inch pitch.

Carriage.—To be 18 inches long. To be fitted to ways on front and back of bed and bear on the same way used for tailstock guide. Rest to be provided with cross feed.

Apron.—To be fitted with gear for longitudinal feed to carriage and cross feed to rest, and lead-screw nut for screw-cutting. Reversing gear for feeds to be put in apron, and safety stop to be provided to prevent feed gear and lead-screw nut from being in operation at the same time.

Tool rest.—To be provided with power cross feed.

Bed.—To be not less than 14 inches wide. To be provided with four ways, two for carriage and two for head and tail stocks. Sides to be joined by web across the top of bed. Depth of bed to be not less than $9\frac{1}{2}$ inches.

Tailstock.—To be held to bed by two heavy bolts. Top to be provided with convenient set-over. Tail spindle to be of steel.

The workmanship must be first class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

All necessary countershafts, pulleys, wrenches, steady rest, and all other appliances to complete lathe ready for operation to be furnished with lathe. Friction clutch pulleys for crossed and open belt to be provided on counter.

CLASS F.

Specifications for one 18-inch slotter.

Machine to be driven by crank with Whitworth quick-return motion. Distance from column to point of tool to be not more than 36 inches.

Compound table.—To be fitted to point of column with longitudinal, transverse, and circular feeds in all directions by power.

Feeds.—To take place always at the upper end of stroke; never during the cut or while the tool is on the return. Range of feeds to be from $\frac{1}{140}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest on a diameter of 50 inches.

Ram guide.—To be adjustable for various heights, and to leave about 22 inches clear between it and circular table when in the highest position.

Material.—The driving shaft to be made of open-hearth steel not less than $4\frac{1}{2}$ inches diameter, containing not less than $\frac{1}{2}$ per cent carbon. All other shafts and feed screws to be made of good machinery steel, and all bolts to be made of steel or refined iron. All nuts frequently used to be casehardened.

Gearing.—Driving pinion to be of forged steel, and all other gearing to be of steel or strong, close-grained cast iron, containing 25 per cent of cold-blast iron.

Countershaft.—To be provided with pulleys for two changes of speed.

Driving cone.—To have four steps for $4\frac{1}{2}$ or 5 inch belt, ranging from about 14 to 26 inches in diameter, giving two changes on countershaft, eight speeds to ram. Slowest cutting speed to be not more than 10 or 12 feet per minute. Cone to be geared to driving crank in ratio of not less than 8 to 1. Main driving gear to be 1 inch pitch, not less than $3\frac{1}{2}$ inch face, and about 45 inches pitch diameter. Largest step in cone to be extra heavy, to serve as balance wheel.

Ram.—To be connected to crank by steel-forged rod of heavy section not less than 32 inches long. Stroke of ram to be 19 inches. Ram to be supported in back by adjustable guide. Ram to be counterweighed, and provided with screw for hand adjustment to any vertical position. Length of ram to be at least 70 inches; more length desirable. In addition to clamps for holding rigid tools, the ram is to be provided with a swinging tool-holder on the lower end to take release tool.

Compound tables.—The lower table should be 48 inches long by 32 inches wide, and have bearing on bed about 24 by 32 inches.

Intermediate table.—To be 32 inches square, and have transverse traverse of about 36 inches. Circular table to be 48 inches in diameter, and fitted with worm wheel of hard bronze, located under circular table, and protected from chips and dust.

Cranks for moving tables by hand to be placed in convenient position for operator, and feeds arranged to be easily engaged or disengaged.

Column.—To be not less than 21 inches wide, and, as nearly as possible, 30 inches deep, with front extended out to form bed for tables. Length of bed to be sufficient to allow circular slotting on a diameter of 50 inches.

Chuck.—A special chuck for holding breechblocks while being slotted must be furnished with machine. The chuck to hold breechblock firmly in position and allow of the same being revolved on its axis for resetting without disturbing the central alignment.

Gearing.—All gearing must be accurately cut, and unless otherwise specified shall be made of strong, close-grained iron, containing 25 per cent of cold-blast iron.

All shafts and screws must be of good quality of steel, and all bolts shall be made of steel or refined iron, and all nuts frequently used shall be casehardened.

The workmanship throughout to be first-class. All surfaces in contact with moving parts must be carefully scraped to good true bearings. All necessary countershafts, pulleys, wrenches, and other appliances to complete machine ready for operation must be furnished.

CLASS G.

Specifications for one open-side combined planing and shaping machine (as built by Pedrick & Ayer).

This machine is 12 feet long by 42 inches wide, and is to be provided with power cross, angular, and vertical feeds.

Bed.—To be not less than 40 inches wide on top. Base to be not less than 4 feet 9 inches wide.

Top of ways for carriage to be 42 inches above the floor line. The whole bed must be massive and very rigid, in order to carry weights up to 1½ tons on the work tables. For this purpose the rear side of the base must be strongly anchored to the foundation. The front of bed is to extend down to the floor, and must be provided with T-slots to hold tables and work.

Work tables.—Two work tables must be provided. They are to be mounted on table saddles. Table saddles to be adjustable lengthwise on bed. Tables to have vertical adjustment on saddles, to allow work up to 40 inches high to go under the projecting arm. Projection of tables from their saddles to be not less than 40 inches. Tables to be provided with T-slots on top and sides for clamping work.

Carriage.—To have bearing on bed not less than 54 inches long by 40 inches wide. Projecting arm to be of strong form, and width of face to be not less than 12½ inches. Tool saddle to have not less than 15 inches bearing on arm. Carriage traverse to be performed by means of a double pitch steel screw of not less than 3⅞ inches diameter, operated by direct gearing and tight and loose pulleys. Driving belts to be not less than 2½ inches wide. All loose pulleys and screw bearings to be bronze lined and self-oiling.

Suitable arrangements are to be made on the carriage to adjust the length of the stroke, and it is desired that these arrangements should permit to adjust the stroke within positive limits, if feasible.

The work is to remain stationary, the tool passing over it.

Feeds.—To be positive and operated by geared frictions. All feeds to be arranged for steel. Cutting speeds from 8 to 16 inches per minute.

Workmanship and material to be first-class throughout.

Gearing.—To be accurately cut, and to be of steel or strong close-grained iron, containing 25 per cent of cold-blast iron. All shafts and screws to be of good machinery steel, and all bolts to be of refined iron. All nuts frequently used must be casehardened.

All bearing surfaces must be accurately scraped to bearing.

Countershaft, hangers, pulleys, wrenches, and all other appliances to complete machine ready for operation to be furnished.

CLASS H.

Specifications for one heavy milling machine (as built by Pedrick & Ayer).

The machine must possess "vertical" and "angular" attachment; it must be adapted for cutting racks and spur and bevel gears up to 40 inches diameter, for profiling or angular milling, combing or drilling at right angles to the main spindle of the machine, cutting up square stock by saws, milling of slots, arcs or circles, dies for sheet metal, square pieces on edge, etc. Bidders to state size of largest and smallest gears the machine will cut.

The spindle to be of steel and the front end to run in solid self-centering boxes. Spindle to be threaded on the end to screw on large inserted tooth-mills, etc. The hole in the end of spindle to receive arbors, bushings, etc.; to be about 12 inches long, 2 inches diameter at outer and 1½ inches at inner end, so as to be practicable for heavy work.

The overhanging arm to be of hammered steel; it should move out to support cutter arbors 26 inches from end of spindle, and should be arranged to be pushed back or moved out of the way entirely when not in use.

The knee to have a bearing of 24 by 14 inches and a vertical movement of 19½ inches. Its movement in line with the spindle to be 12 inches.

Table or platen to be 48 by 14 inches, horizontal feed 12 inches, transverse feed 32 inches. It should have three T-slots for ¾-inch bolts on top. It must be placed end for end or in line with spindle, and its feed is to operate automatically while in any position. There must be three feeds, one for table, one in line with the spindle, and one up-and-down feed, all reversible and automatic, with automatic stops.

All feeds to be arranged for steel milling. Feed to be driven by a 2-inch belt, and motion further conveyed through cut-gears and clutches. It must be reversible, and operated by a lever of such construction as to remain in any position desired. This lever is to control all different feeds in all directions, and to work with automatic stops. All feed gears to be of steel, cut. Dials to read in decimals. Index head to swing 16 inches. Vise to swing at any angle from 0 to 90 degrees, to have hardened steel jaws 8 by 2 inches, and to open 5½ inches.

Countershafts to have two clutch pulleys, and to have facilities for oiling while pulleys are reversing. Hangers, drip cups, shifter rod, and all necessary appurtenances to be furnished for countershafts.

With this machine will be furnished index head with back center, vertical and angular attachment, Universal vise chuck, and such other attachments as are manufactured by Pedrick & Ayer for this machine.

It is also desired that an attachment be furnished for automatically threading translating rollers for 8, 10, and 12 inch breech mechanism. The thread of these rollers is reversing (changing from right-hand to left-hand thread) and the pitch of a portion of it is variable. A drawing of these translating rollers will be furnished on application. Bidders will submit a sketch of the attachment for threading, if such one is feasible.

CLASS I.

Specifications for one horizontal boring, drilling, and milling machine.

This machine is to bore anywhere in a space of 9 feet wide by 6 feet high.

Machine to consist of a heavy column 10½ feet high, mounted on a bed plate approximately 14 feet long. The column to be moved along the bed plate by power operating through worm gear and rack, and to have horizontal movement of 9 feet on bed. The face of column to be not less than 30 inches wide, fitted with flat ways, upon which is fitted a heavy saddle 40 inches square, carrying the spindle.

Saddle.—To be accurately fitted to face of column and provided with gib to take up wear. Saddle to be 40 inches square, and counterbalanced by weight hung inside the column; weight to be built up of pieces easily handled. Saddle to have vertical travel of 6 feet by heavy steel screw.

Boring spindle.—To be 5½ inches diameter; to be made of open hearth steel containing ½ per cent of carbon. Spindle to be driven by two splines ⅝ inch wide, and slide in a heavy revolving sleeve of strong cast iron, driven in either direction, controlled by reversible lever conveniently placed on saddle. Spindle to have traverse of 4 feet through sleeve.

Spindle feed.—To be transmitted to spindle by rack and pinion. Eight changes of feed to be provided, ranging from $\frac{1}{80}$ inch to $\frac{1}{10}$ inch per revolution. Hand-feed and quick return by hand to be provided.

Spindle sleeve.—To revolve in bearings, composed of 90 parts copper and 10 parts tin.

Feeds for milling.—Six feeds, ranging from $\frac{1}{24}$ inch to ¼ inch per revolution of spindle, to be provided for the column and saddle. To be reversible in either direction, horizontally for feeding column and vertically for feeding saddle. In addition, a quick traverse motion of 60 inches per minute, reversible in either direction, to be provided for the column and saddle. All of the above feeds to be controlled by hand levers conveniently placed on the front of saddle. All speeds to be suitable for steel.

Bed.—To be 54 inches wide and 20 inches deep at least. To be fitted with flat ways for column. Web to be carried across the top without openings. Center part of bed to be depressed the full length and receive the driving and feed shafts and feed rack. Column bearing on bed to be 54 inches wide, 57 inches long.

Driving cone.—To have six steps for 4-inch belt, ranging from 9 inches to 22 inches diameter. To be back geared, giving 12 changes of speed. Cone to be geared to spindle in a ratio of from 18 to 1 or 20 to 1. Motion from cone to be transmitted by heavy longitudinal shaft running under column the full length of bed, shaft to be at least $2\frac{15}{16}$ inches diameter. Vertical shaft in column to receive motion from longitudinal shaft by bevel gears. Shaft to be $2\frac{15}{16}$ inches diameter and geared to spindle in ratio of 3 to 1. Cone and back gear to be placed at one end of bed.

Work table.—To be placed on side of main bed; to consist of a heavy bed fitted with flat ways and T-slots for bolts. Bed to be approximately 5 feet wide on top and extend 12 feet out from main bed. Should it be desirable to change dimensions or direction of location of table, the contractor will be notified of it in time. Work table to be mounted on bed just described, to be approximately 5 feet wide and 7 feet long.

To be well supplied with slots for bolting work, and provided with center-bearing for circular table.

Circular table.—To be approximately 6 feet in diameter and arranged to revolve on rectangular table. To be provided with divisions and index on circumference, and facilities for clamping in position. To be easily removable when desired.

Back rests.—Two heavy back rests of approved design are to be provided. The breech back rest is to be a single casting or housing, its bore forming a semicircle of 32 inches radius. It is to be provided with three jaws, of 12 inches by 6 inches section, face to be bronze capped. Adjustment of jaws for diameters from 64 to 60 inches.

The housing is to be provided with a rotating chuck ring in halves, securely doweled and clamped together. Rotating chuck ring to have a close and very accurate fit in bore of housing. It is to be heavily flanged, and is to be provided with six adjustable jaws with hardened steel faces. Faces to be of sawtooth pattern. Adjustment of jaws for diameter from 48 to 44 inches.

The chuck ring is to be provided for rotation with a heavy worm gear and worm, the worm shaft to be operated by means of a ratchet lever from the side of the rest.

The breech-back rest is to be located on the work table and to be clamped to same by means of the T-slots.

The muzzle rest is to consist of a lower half or base only, having a semicircular bore of 18 inches radius. It is to be provided with three jaws of 6 by 4 inches cross section, bronze capped. Adjustment of jaws to be for diameters from 36 to 30 inches.

The muzzle back rest is to be clamped to a heavy cast iron floor plate, about 5 feet wide by 8 feet long. Floor plate to be provided with T-slots for longitudinal adjustment of rest. Floor plate to be set on foundation provided by the Department.

Workmanship and material to be first-class throughout. All surfaces to be carefully scraped to good and true bearings, and all quick-running shafts to have composition-bearing bushes of 90 copper and 10 tin. All shafts and screws not otherwise specified to be of good machinery steel. All gearing to be of steel or strong, close-grained iron, containing 25 per cent of cold blast iron.

All bolts to be of refined iron, and all nuts frequently used to be casehardened.

Countershafts, pulleys, hangers, wrenches, and all other appliances to complete machine ready for operation to be furnished with machine.

CLASS K.

Specifications for one 60-inch automatic gear-cutting machine.

This machine is to cut spur gears up to 60 inches diameter, 10 inches face, and 2 inches pitch; also bevel, worm, and screw gears. Worm-gears are to be cut by an automatic continuous motion of hobb and blank; the blank is to be rotated in unison with pitch of hobb. The machine is to be automatic in all its movements; after being set and started, the cutter is to cut through the gear blank; returned to the starting point, it is to rotate the dividing wheel to the exact place for the next tooth, and to repeat the operation indefinitely without further attention from the operator. The machine is to be as simple as possible, and to make all the motions as nearly positive as possible. Arrange-

ments must be made for supplying oil direct to the cutter and for removing all cuttings. A gong is to indicate when a gear is finished.

The feed motion to be by differential gearing, connected by hardened steel clutches.

For the cutting of bevel gears provision is to be made for getting the "set over" with unfailing accuracy and certainty, obviating the usual "cut and try" system.

All motions to be quiet and without shock.

The main head is to be raised and lowered by hand and by power, and is to be supported between two strongly braced uprights, having V's on their front and back faces, thus securely locking all together. The mandrel for holding work is to have an outer support direct from the base of the machine.

The dividing wheel is to be of large proportions, made in two parts, and having its teeth of such angle as to best resist all side strains. It is to be self-locking. The cutter spindle is to be of crucible tool steel. It is to be driven by a train of gears of large proportions, and its speed is to be varied by change gears. Power is to be applied without the aid of belt tighteners.

The feeds are to have a wide range, driven positively by change gears. The slide is to be provided with a positive quick return.

The machine is to have an automatic "safety-stop" motion.

A full set of change gears is to be furnished to cut all numbers from 10 to 100, all but prime numbers to 300, and others to 360.

A suitable receptacle for the lubricant must be provided.

A rack cutting attachment is desirable but not absolutely necessary, and the price for the machine will be given with and without it. All sliding surfaces must be accurately scraped and all important bearings should be bronze-bushed.

All countershafts, pulleys, hangers, wrenches, index, etc., and anything necessary for the completion of the machine in running order is to be furnished.

The workmanship must be first-class throughout.

(4772–'93.)

APPENDIX 25.

SPECIFICATIONS FOR AN ARC AND INCANDESCENT ELECTRIC LIGHT AND POWER PLANT FOR THE WATERVLIET ARSENAL, WEST TROY, N. Y.

Plant.—The plant is to consist of six 45-kilowatt dynamos, switchboards, governing, indicating, and safety appliances, wiring, lamps, poles, fixtures, etc., as specified hereafter.

The contractor is to furnish the whole plant in complete running order, at the Watervliet Arsenal, without any expense to the United States, except that the Ordnance Department will provide the necessary foundations for the dynamos and will furnish the belt power to drive dynamos, but nothing else. The contractor will furnish foundation plans at the proper time for the erection of masonry foundations. The present dynamos and the armature of the 120-ton crane motor will be at the disposal of the contractor, who will make proper allowance in his bid.

The contractor is to furnish six compound wound dynamos of 45 kilowatts capacity, each compounded for 10 per cent line loss at full load. Four dynamos to be located in the gunshop, two dynamos in the shops below the canal. One dynamo at the lower shops should be provided with a suitable switch, rheostat, etc., in order to use it as a motor for furnishing power to operate lower shops from plant at upper shops when required. The dynamos to be thoroughly efficient, economical, and well constructed, and bearings to be self-oiling. When run at constant speed they are to furnish current at practically uniform electrical pressure, in order that any number of lamps may be turned on or off without danger of injury to either dynamos or lamps. The dynamos are to be so constructed as to furnish an amount of current proportionate to the number of lamps burning, and when running at approximately full load to convert into electrical energy at least 90 per centum of the mechanical energy received at their pulleys, and to maintain ten 16-candle-power lamps of 3.6 in. watts per candle or twelve 16-candle power lamps of 3.1 in. watts per candle for each horse-power. The armatures to be well balanced, and the shafts sufficiently lubricated.

The commutator sections to be made of hard copper, and to be carefully insulated from each other. The brushes to have ample bearing surfaces, and there shall be no undue sparking or undue wearing away of the brushes or commutators when running at full speed or at full load or less. The brush holders to be so constructed as to be thrown back entirely from the commutator when desired. All parts of the dynamo to be so proportioned that none of them will heat unduly when running at *full load*.

The contractor to furnish for each dynamo a cast-iron base, insulated from the dynamos by means of hard-wood blocks, and supplied with a device by which the tension of the belt may be changed without stopping the dynamos. The contractor is also to replace the present 500-

volt Thomson-Houston armature of the motor operating the 120-ton one motor crane by a new 220-volt armature, and change the field windings of said motor if necessary, and provide all other arrangements required to operate the crane properly by the new 220-volt system. He will also furnish and connect in the operating cage of this crane a voltmeter and an ammeter of approved dead-beat standard type.

Instruments.—The contractor is to furnish the following instruments: Five potential or pressure indicators, suitable to be kept in circuit constantly when the plant is in operation; three neutral ammeters; six ammeters, each of 360 amperes capacity; six fire-proof rheostats, to vary the pressure at which the current is delivered from each dynamo to the mains, and two three-point ground detectors, one for each station.

Switches.—The contractor is to furnish one combination switch for each set of two dynamos, by which each pair of dynamos may be connected to the line on the three-wire system, or if at any time in case of light load it may be deemed advisable to throw the load on either dynamo of the pair, into a two-wire system, using the neutral wire as one side of the three-wire system, the two outside wires serving as the other side of system. It may be readily done by the manipulation of the aforesaid combination switch.

The contractor shall also furnish for the additional lights to be installed in the gun factory the following switches and place them on the switch-board: Two 100-amperes triple-pole knife switches, for incandescent lights; one 50-amperes double-pole knife switch, for arc lights and for the various sections of the shops below the canal, and four 50-amperes triple-pole knife switches, to be placed on the switch-board at the water-power station in the lower shops; all switches to be properly connected to their respective circuits.

The 50 lights to be used in lighting the grounds to be controlled by two double-pole knife switches, each of 50 amperes capacity, said two switches to be located in the guard-house, in order that the current may be cut off of these circuits when not required.

He will also provide on the switch-board three double-pole knife switches of at least 400 amperes capacity each, ready for connection with feeders from crane circuits. All of the knife switches to be mounted on slate and to have ample contact surfaces for carrying the current required.

A suitable switch shall be placed in main feeder lines between upper and lower shops, and so arranged that the power from the dynamos at the lower shops can be utilized to operate the crane circuits independent of the dynamos of the upper shops.

A suitable switch of ample capacity shall be provided to cut out the feeder from lower shops to quarters at switch-board in lower shops; likewise another switch to cut feeder at upper shops to quarters at switch-board in upper shops, in order to make power plants at upper and lower shops independent of one another.

Switch-boards.—The contractor shall furnish two skeleton switch-boards of ash, and shall place the instruments and switches on same and properly connect them to the various circuits and dynamos; all wires to be supported on porcelain or hard rubber.

The leads from each dynamo to the switch board shall be equal in capacity to 400,000 circular mills.

The contractor will take possession of, and may utilize as far as consistent, all switches, circuit breakers, and other electric appliances at present in the dynamo room.

Lamps.—The contractor is to furnish and put in position—

In the gun factory, as indicated in the accompanying plans, three single carbon arc lamps, thirty-five 50-candle-power incandescent lamps, and two hundred and fifty 16-candle power incandescent lamps.

In the grounds, for lighting walks and drives, fifty 50-candle-power incandescent lamps.

In the shops below the canal, marked A, B, C, D, and E, two hundred 16-candle-power incandescent lamps, one hundred and eighty of which will be portable.

In the offices and draughting room the following:

In building marked F, fifteen 16-candle-power incandescent lamps.

In building marked G, fifteen 16-candle-power incandescent lamps.

In building marked H, fourteen 16-candle-power incandescent lamps.

In quarters, barracks, dwellings, guard-house, etc., the following:

In quarters No. 1, forty-two 16-candle-power incandescent lamps.

In quarters No. 2, thirty-five 16-candle-power incandescent lamps.

In quarters No. 3, thirty-five 16-candle power incandescent lamps.

In quarters No. 4, thirty 16-candle-power incandescent lamps.

In quarters No. 5, thirty 16-candle-power incandescent lamps.

In quarters No. 6, thirty-five 16 candle-power incandescent lamps.

In quarters No. 7, thirty five 16-candle-power incandescent lamps.

In quarters No. 8, thirty seven 16-candle-power incandescent lamps.

In hospital No. 9, twenty-two 16-candle-power incandescent lamps.

In quarters No. 10, twelve 16-candle-power incandescent lamps.

In barracks No. 11, twenty-seven 16-candle-power incandescent lamps.

In dwellings No. 12, forty-nine 16-candle-power incandescent lamps.

In guard-house No. 13, five 16-candle-power incandescent lamps.

In stables No. 14, six 16 candle-power incandescent lamps.

NOTE.—Quarters Nos. 2 and 3 are already wired for 24 lamps each, but have no lamps, and the contractor is to furnish any additional wiring required and is to provide lamps to the extent called for in the above list.

All breakages in starting up and testing the plant must be made good by the contractor, who is also to guarantee an average burning life-time of 600 hours without serious discoloration of bulbs, if lamps are run at their normal pressure.

Sockets.—The contractor is to furnish and properly connect polished brass lamp sockets, to be provided with key switches for the individual control of all 16-candle-power lamps; to be keyless for all 50-candle-power lamps.

Location.—Dynamos and switch-boards to be located as shown on the accompanying plans or as directed by the commanding officer.

Lamps to the number and of the description above specified to be located throughout the buildings as indicated in the accompanying plans or as directed.

Wiring.—The whole system to be so arranged by the contractor that 220-volt motors can be operated in connection with 110 volt incandescent lamps from the same dynamos and at the same time. When motors are not needed and the load is light, the whole system of lighting should be arranged to be thrown into a two-wire 110-volt system. The neutral or middle wire in all cases should be of a cross section or capacity equal to that of either of the outside wires of the system. The main feeders to be located as shown in the blue print.

Six circuits in the gun factory to have separate control at the switch-board.

First, to the arc lights.

Second, to the incandescent lights in the west half of building.

Third, to the incandescent lights in the east half and small gun shop.

Fourth, to the main 220-volt circuit for 120 ton crane.

Fifth, to the main 220-volt circuit for 60-ton crane.

Sixth, to the 220-volt circuit for 30-ton crane in west aisle.

Wires to outlets for portable lamps between main crane columns in the gun factory are to be run under the flooring on porcelain insulators, but it is preferred that a convenient arrangement be made by running the wires open to view and attaching the switches on the crane columns, and furnish cables of sufficient length for the work to be done in gun lathes, etc. Remaining wires therein to be run open to view on porcelain insulators or cleats, except in cases of probable exposure to injury, where double groove wood molding will be used and special rubber-covered wire with outside protecting braid equal in quality to Clark, Grimshaw, Edison E. M. W., or Bishop.

In the quarters, offices, barracks, etc., where wires can not readily be concealed, molding shall be used.

In the quarters all wires should be concealed without molding wherever possible. All wires must be supported on porcelain or hard rubber, except where it becomes necessary to use molding.

Crane feeders.—The contractor shall furnish and put in position and connect to present crane trolley wires 1,100 feet of 0000 B. & S. gauge wire or its equivalent, so as to adapt the feeders for the 220-volt system.

All conductors to be covered with three-braid weather-proof insulation of the best quality, except where specified otherwise and in damp locations, where special wires, as specified above, are to be used, and to be of such capacity as to avoid any undue heating.

The loss of potential between the dynamos and lamps in the circuit is not to exceed 12 per centum under any condition of load up to full load.

All copper used to be of at least 96 per centum conductivity.

The wire to be used in continuous lengths as far as possible to avoid joints; where joints are necessary the wire to be carefully soldered, the excess of acid removed, and a covering of tape and compound put on to make the insulation of the joint fully equal to that of the rest of the wire. Where it is necessary to pass through walls or floors the wires are to be encased in tubes of hard rubber; wires to be supported by cleats or insulators not more than six feet apart, except in dynamo room.

Before the current is turned on a careful test of all wires is to be made to show that they are free from grounds and short circuits.

The work is to be done in accordance with rules and regulations of the Underwriters' Association of New York State, and to the satisfaction of the commanding officer.

The lowest point of the arc lamp over shrinkage pit should not project more than 18 inches below iron rods of roof truss.

The wires of portable 16-candle-power lamps must be of sufficient length to allow a lateral movement of lamps for a distance of 5 feet, when at a height of 5 feet above floor line of building.

No part of the 50-candle-power lamps should project below under line of iron girders.

All portable 16-candle-power lamps marked "A" on the plan can not be put in position now, unless wires and switches can be attached to the crane columns (which must be stated in the bid), but the contractor will

bring wires to the nearest possible point, and is to furnish all necessary wires, switches, fixtures, and lamps for the completion of the work by the Department at a later date.

Safety devices.—The contractor is to insert in the system of wiring strips of fusible metal so proportioned as to melt before any of the wires receive a dangerous excess of current. These fusible strips are to be inserted so as to protect the wiring for the smaller groups of lamps as well as for the larger groups, so that in case of injury to any part of the system interference with the regular system service will not extend beyond the portion directly affected.

The strips are to be placed in devices made of porcelain to avoid all danger of fire from heat of the melted strips. The connections to the strips to be so arranged that they may be readily removed, and leave the wiring in sections entirely free from each other for convenience in testing.

Fixtures.—The 50-candle-power lamps in the gun factory are to be provided with 16-inch porcelain or porcelain-lined reflectors, supported between and beneath the iron girders.

Portable lamps to be each provided with a heavy wire guard and 20 feet of flexible cable. The entire fixtures should be readily detached from the floor sockets or other sockets. Office fixtures, except cable attachments, will be provided by the Ordnance Department, the remaining 16-candle-power stationary lamps except those in quarters No. 1 to No. 8 to be suspended by a flexible conductor attached to brass castings mounted on porcelain, so arranged that the current is passed through fusible strips. These lamps are to be provided with shades concaved and white beneath, or with porcelain shades, as the commanding officer may prefer. Holders for portable lamps on machines, etc., will be provided by the Department.

All lamps in quarters No. 1 to No. 8 are to be provided with shade holders, but no shades will be furnished. These lamps will be attached to existing chandeliers or wall brackets, or otherwise as directed.

The 6 stable lamps are to be provided with wire guards.

OUTSIDE CONSTRUCTION.

Poles.—The contractor shall furnish and set in place thirty 30-foot cedar poles of at least 7 inches diameter at the top; same to be straight, well shaped, painted with two coats of oil paint of such color as the commanding officer may select, and shall properly set same in the ground not less than 5 feet. These poles to be used on the main feeder lines; also the proper number of 26-foot octagonal poles with 6-inch square base, hard pine or cedar. These poles to be set 4 feet 6 inches in the ground and to be used only where the wires are not larger than No. 6 B. & S.

Cross arms, pins, and insulators.—The contractor is to furnish and put in place a suitable number of cross arms, pins and deep grooved double petticoat glass on main feeder lines, arms and pins to be extra heavy.

Cross arms on main feeder lines to be substantially braced by means of strap iron braces, secured by lag screws to pole and arm.

Feeders, etc.—The contractor is to furnish and place on the poles the following described feeder wires and connect the same through suitable switch-board arrangements:

First main feeder.—Station at lower shops to gun factory, 4,300 feet of 0000 B. & S. wire.

Second feeder.—Gun factory to quarters, 3,300 feet of No. 0 B. & S. wire.

Third feeder.—Station at lower shops to quarters, 3,900 feet of No. 0 B. & S. wire.

Fixtures for outside lighting.—Lamps to be attached to poles by means of goose necks in a substantial manner, and to be furnished with a small hood and concaved white porcelain reflectors to diffuse the rays from the lamps.

Separate bid.—A separate bid is required for the delivery of any additional 16-candle-power or 50-candle-power lamps; for furnishing wire, fixtures, and labor; for putting them up and connecting them with the system at such places as the commanding officer may designate.

Instructions.—The contractor is to furnish an expert to run the plant for a period of twenty days and to instruct such person as the commanding officer may designate in the care and manipulation of the apparatus.

Bidders will state the time required for the delivery and installation of the plant in complete working order.

For any delay in the completion of the plant beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price the sum of $20 for each and every day (excepting Sundays) after said date until the completion of the contract.

Payment will be made upon final acceptance of the whole work by the United States, after a continuous successful operation of the plant of twenty working days.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, United States Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

SPECIFICATIONS FOR ONE 60-GROSS-TON, SINGLE-TROLLEY, OVERHEAD TRAVELING CRANE FOR THE ARMY GUN FACTORY AT THE WATERVLIET ARSENAL, WEST TROY, N. Y.

This crane is to be erected and operated in a building, with a clear space of 50 feet between floor and roof-chord, and to travel on a special steel rail, 120 pounds per yard, of shape and dimensions shown on drawings. This rail is resting on iron-plate girders, of 32¾ inches depth, supported on iron columns, spaced 18 feet and 18 feet 4 inches between centers. The top of the supporting girders or runways is 34 feet 3⅝ inches above the floor line. One of the runways forms the extension of the existing runways of the 30-ton traveling cranes, while the other runway, on the east side, is 10 feet distant from the existing runway on that side, and is quite close to the wall of the building. As all runways for the 30-ton and 60 ton cranes have the same height above the floor line, the 60-ton crane will have to clear the eastern runway of the 30-ton cranes, because both the 60 and 30 ton cranes must traverse a certain portion of the central section of the factory. Plans showing the location and construction of the craneways will be furnished on application.

The crane-ways and their top rail are erected and are the same on which the existing 120-ton traveling crane is running now.

Builders of cranes are invited to submit bids, with detailed plans and specifications, for the construction and erection in complete running order of one overhead traveling crane of 60 gross tons effective capacity, 60 feet span between centers of runways, which, fulfilling the general conditions herein specified, will give the maximum possible lift. (Lift must be 50 feet.)

The contractor will furnish, deliver, and erect in place, at his own risk and expense, the bridge trolley, hoisting, and other gear, chain, hook, driving shafts, motors, trolley, wires, feeders, lamps, instruments, etc., and all that may be required to complete and operate the crane to its full capacity and to the satisfaction of the commanding officer.

The crane will be accepted after a satisfactory trial during fifteen consecutive working days, if practicable, with loads not exceeding the maximum.

The contractor will be required to submit with his bid for the work a full statement of the requirements as to electro-motive power, if in excess of that specified.

GENERAL CONSTRUCTION.

The crane is to consist of a transverse bridge, arranged to travel upon the longitudinal tracks, and carrying a trolley capable of traveling transversely upon the bridge. In addition to the main hoist there will be an auxiliary hoist. The several motions of the crane, namely, bridge travel, trolley travel and hoisting and lowering, are to be effected by separate electric motors, of which there will be four, as follows:

One for the bridge travel, to be located on the bridge.
One for the trolley travel,
One for the main hoist,
One for the auxiliary hoist,
} to be located on the trolley.

Electric current for the operation of the crane will be supplied by the Department at the switch-board of the dynamo room in the gun shop. The contractor will bring the trolley wires to this switch-board and connect them there to the switches provided for. The contractor will also provide an automatic circuit-breaker of approved construction; with proper connections for same, in the connection of the trolley wires with the switch-board.

The trolley wires must be supplied by the contractor on insulated rollers supported on the braces of the crane runways. But in case the construction of the new crane should permit the use of the trolley wire of the 120-ton crane, and if this should be preferred by the Department, the contractor will have to provide feeders of sufficient capacity to maintain the potential on the farthest point of the trolley wire with both cranes working simultaneously at their maximum rated capacity. The maximum loss in this case must not exceed a difference between the voltage at the motors and at the dynamo of more than 5 per centum.

The length of the longitudinal travel or of the runways will be 510 feet.

The trolley travel should admit of operating the main hoist within the largest possible area of the floor space covered by the crane runways.

In order to prevent over travel in either direction the crane bridge as well as the trolley must be provided with automatic stops. Automatic stops must be provided also in order to prevent collision or any

injury to machinery with the other (120-ton) crane running on the same track or with the nearest 30-ton crane of 50 feet span. These stops must be gradual in their effect and positive in their action at any point of the travel. The speed of the several motions when the current is at its normal potential will be as follows:

Bridge travel, not less than 50 feet nor more than 100 feet per minute.

Trolley travel, not less than 50 feet nor more than 100 feet per minute.

Main hoist, to hoist a maximum load of 60 gross tons at 6 feet per minute. This hoisting speed will answer for all loads above 10 tons.

Auxiliary hoist, to hoist loads up to 10 gross tons at the rate of about 20 feet per minute.

The motors for the several operations must be of the following capacity at least:

For the bridge travel, of 15 horse-power.

For the trolley travel, of 10 horse-power.

For the main hoist, of 30 horse-power.

For the auxiliary hoist, of 15 horse-power.

In case the construction of the crane requires the application of greater powers than those stated, in order to obtain the necessary speeds of bridge, trolley, and hoists with the maximum load, as given above, crane-builders will state so in their bids.

Bridge.—The bridge is to consist of two plate-girders of box section of wrought iron or mild steel, of such cross section, depths and construction as to limit the fiber stress in the upper or compression members of each girder to a maximum of 7,000 pounds per square inch, and in the lower or tension members to 8,000 pounds per square inch net section when carrying a load equal to the full nominal capacity of the crane at the center of the bridge, and in addition to such load, the entire weight of the bridge, trolley, and connecting parts. The two girders forming the bridge to have such lateral stiffness as to be independent of each other, and the construction of the trolley to be such as to enable the hook and lower sheave or chain blocks to rise between the girders, thus giving the maximum height of hoist. Each girder is to be composed of two webs, secured by internal and external angles with broad top and bottom cover plates, securely riveted together and of curved form on the lower flanges. Distance pieces will be riveted between the webs of each girder at suitable intervals to insure lateral stiffness. These distance pieces must be machined on their ends and on their top face, so that the top cover plate will rest directly upon them. The rail supporting the trolley will rest directly over the center of these distance pieces, in order to transmit the load equally through the two web plates of each girder. This rail must be especially heavy, and must have a width of not less than 4 inches across the head. The material for girders is to have a tensile strength of not less than 55,000 pounds nor more than 65,000 pounds per square inch, with an elongation of not less than 20 per centum in 8 inches.

The girders will rest directly upon box-section carriages at each end. The connections between these carriages and the girders must be so rigid that raking or getting out of square will be impossible. Each end carriage will contain 4 track wheels of cast steel of not less than 36 inches in diameter, mounted in pairs in equalizing or compensating trucks, to insure an equal load on all wheels at all times. The wheels must be turned or ground to the same diameter. They must be of proper dimensions and form on tread and flanges to suit the profile of

the rail on top of the crane runways, and must be flanged on both sides.

Trolley.—The trolley is to travel directly on top of the bridge and its construction should enable the hook to reach as close as possible on either side. It is to be provided with the motors for main hoist, auxiliary hoist, and trolley travel. It is to be of the double drum type, one drum winding on either end of the hoisting chain. The drums are to be of such size that the hoisting chains will lead practically in a vertical line from the chain heaves in the bottom block when this block is in its highest position. The chain-drums will be turned and grooves cut from the solid metal. The grooves must be of ample pitch to prevent wear and tear of coils while winding, and to be of such depth that the vertical links of the chains will bear on the bottom of the grooves while the horizontal ones will bear on the face of the drum. Their arrangement will be such that the load will be always suspended from the center of the trolley; and the weight of load and trolley will at all times be sustained equally by each girder. No overlapping of the chains will be permitted at any time. The trolley is to be carried on four track wheels of cast steel of not less than 30 inches diameter, turned or ground to a uniform size, and having a face of such width as to run on a rail having not less than 4 inches width across the head.

Auxiliary hoist.—The auxiliary hoist is to be embodied in the trolley and must be independent from the main hoist or any other operations. It must be capable of lifting 10 gross tons at a speed of 20 feet per minute. The hook of the separate hoisting mechanism is to be located as near as possible to the center of the main hoisting chain.

Hoisting chains, etc.—The main blocks are to give a practically vertical lift throughout.

The hoisting chains must be of special quality. Tensile strength to be 52,000 pounds per square inch, elongation to be 15 per cent, and contraction at point of fracture 20 per cent. Links to be as short as possible (Bradley or equal).

There should not be less than 6 nor more than 8 strands of chain.

Operating cage.—The operating cage is to be suspended beneath and to one side of the main girders at the western end of the bridge, to allow the full travel of trolley and hook so as to approach as near as possible the longitudinal runways. The cage will be connected with suitable footways across the bridge and with other platforms to give convenient access to all parts of machinery. All platforms and footways will be provided with grated floors and with neat and substantial hand railings. All manipulating levers must be grouped entirely on the operating cage. They should be as few as possible and arranged in such a manner as to prevent confusion. The electric outfit of the cage must include a volt-meter and an ammeter of approved dead-beat standard type, suitably connected and properly located so that the operator may at any moment observe the conditions of the current.

All necessary rheostats, reversing switches, fuse boxes, and main switch, together with all the necessary apparatus for controlling each and every motion of the crane (which must be entirely independent of each other), must be furnished and suitably arranged.

Automatic brakes.—Each hoisting train will be fitted with an automatic magnetic brake, operated through the means of solonoids, so that "racing" or accidental running down of load will be impossible except from breakage of parts between the brakes and the load. These brakes

will be entirely automatic, and will not require any manipulation on the part of the operator.

Motors.—The motors are to be of water-proof type with steel castings forming the fields of the motor. The armature driving pinion and the gear into which it meshes are to be encased in a brass casting, which is filled with oil. This type of motor is practically noiseless in its operations. All motors are to be flexibly hung in position with self-oiling bearings. They should be of the flat field type, having wrought-iron fields with self-oiling boxes. All loose running bearings must be bronze bushed.

Attention should be given that spare parts to be kept may be interchangeable for as many motors as possible.

Rheostats.—They are to be fitted with Elihu Thomson's patent blow-out magnet for blowing out the sparks where the break is made, in order to avoid kicking in the fields, causing burning where break is made.

Gears, bearings, clutches, lubrication, etc.—All gears throughout the crane are to have accurately cut teeth, excepting the main master wheels (attached to the chain-drums) and the pinions gearing into the same, for each hoisting apparatus, which shall be shrouded. Pinions of less than 30 teeth must be made of forged steel.

The most careful provisions must be made for continuous and thorough lubrication of all journals and bearings, and great care will be taken to reduce the friction of the mechanism and produce a machine of highest efficiency. No clutches, worm gears, or miter gears are to be used therefore in the construction. All parts of the crane mechanism must be of easy access for repairs.

Lights.—All parts of the crane must be properly lighted with incandescent lamps, to insure observation of the mechanism at all times.

Painting.—All parts to be neatly painted, excepting the bright or finished parts, and these to be slushed.

Drawings.—Bidders will submit with their proposals drawings of the crane which they propose to furnish. Bidders will be furnished with drawings on application, showing the position and dimensions of the crane supports. All drawings necessary for the design, construction, erection, and operation of the crane will be provided and paid for by the contractor, who, at the completion of the work, will furnish the Ordnance Department with a complete set of working drawings, or prints, of the crane and its appurtenances.

Weights of the different parts.—Bidders will furnish a clear and detailed statement of the weights of the different parts of the crane proposed, also the maximum load, which, under certain conditions, is likely to fall on the track wheels.

Delivery.—The contractor is to deliver the crane and all its parts complete, so as to be in working order when resting on the runways and connected to the switch located in the dynamo room of the gun factory building at the Watervliet Arsenal, West Troy, N. Y. He is also to erect said crane on the runways in complete working order by his own employés and under his own superintendence. Railroad tracks, connecting with the tracks of the Delaware and Hudson Canal Company, run into the building, and the existing 120-ton crane may be used by the contractor to transport heavy parts of the crane from the cars to the place of erection, as far as this does not interfere with the operations of the gun factory.

The contractor will furnish all material and all skilled and unskilled labor and superintendence necessary for the delivery of the crane on

the floor of the factory and for the erection of the same on the runways and its starting. He has to comply with the State and other laws, and will be solely responsible for any injury to life and limb of his employés, or for any damage done to Government property by his employés.

No labor or material of any description will be furnished by the Ordnance Department.

Time to complete the work and forfeitures for delay.—The bidders will state the time within which they will deliver the crane with all its appurtenances at the place mentioned above, and also the time for erecting the crane on the runways in complete working order, from the date of the award of the contract.

For any delay in the completion of the crane beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price, the sum of $20 for each and every day (excepting Sundays) after said date until the completion of the contract.

Payments under the contract.—Payments will be made in five installments of twenty per cent each, as the work progresses, upon the certificate of the inspector as to the proportionate amount of work from time to time. Ten per cent will be retained from each payment until the final completion and acceptance of the crane.

Insurance must be effected, and, if necessary, renewed from time to time, in favor of the Government, subject to the approval of the Chief of Ordnance as to the amount thereof and the companies assuming the risk, sufficient to cover installments paid from time to time; it being understood and agreed that the title of the property in the course of construction shall be and remain in the United States.

In case of failure on the part of the contractor, at any time prior to the completion of the contract, to faithfully perform the obligations thereof, the United States shall be entitled to either enforce its lien on the property, in order to secure the repayment of advances made, or to enter and take possession and complete the work (there or elsewhere) at the risk and expense of the contractor.

In case the latter course shall be adopted, and upon a final accounting to be had between the United States and the contractor after such completion, the total cost of completing the work shall be added to the total amount of advance payments previously made to the contractor. If the cost of completing the work added to the payments previously made to the contractor shall be found to be less than the contract price the contractor shall be entitled, upon final settlement, to receive the amount of the difference thus obtained; but if such aggregate shall exceed the contract price, the contractor shall reimburse the United States to the amount of such excess.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, United States Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

SPECIFICATIONS FOR ONE 30-GROSS-TON, SINGLE-TROLLEY, OVERHEAD TRAVELING CRANE FOR THE ARMY GUN FACTORY AT THE WATERVLIET ARSENAL, WEST TROY, N. Y.

This crane is to be erected and operated in the west aisle of the south wing of the gun factory. Plans showing the dimensions of the building and of the construction of the runways will be furnished on application. The runways and top rail on same are in place ready for the reception of the crane. The height from the floor to the underside of the girders forming the lower roof chord is 18 feet 6 inches; the top of the rail of the crane runways is 14 feet above the floor line, leaving a clear height of 4 feet 6 inches between top of rail and lower roof chords. The profile of the rail on which the crane is to travel on top of the runways is shown in the blue print. The same rail is used on all crane runways of the factory. The span between centers of runways is 19 feet 10½ inches, and the length of the runways over which the crane is to travel is 234 feet.

Builders of cranes are invited to submit bids, with detailed plans and specifications, for the construction and erection in complete running order of one overhead traveling crane of 30 gross tons effective capacity, 19 feet 10½ inches span between centers of runways, which, fulfilling the general conditions herein specified, will give the maximum possible lift. It is required, however, that the hook should be raised at least 14 feet above the floor line.

The contractor will furnish, deliver, and erect in place, at his own risk and expense, the bridge trolley, hoisting and other gear, chain, hook, driving shafts, motors, trolley, wires, feeders, lamps, instruments, etc., and all that may be required to complete and operate the crane to its full capacity and to the satisfaction of the commanding officer.

The crane will be accepted after a satisfactory trial during 15 consecutive working days, if practicable, with loads not exceeding the maximum.

The contractor will be required to submit with his bid for the work a full statement of the requirements as to electro-motive power, if in excess of that specified.

GENERAL CONSTRUCTION.

The crane is to consist of a transverse bridge arranged to travel upon the longitudinal tracks and carrying a trolley capable of traveling transversely upon the bridge.

The space available for this crane is shown in the drawing, and no part of it or its mechanism, except hoisting chain and lower block with hook, must project outside of these lines. The clearance lines, outside of which no part of the crane must project, are: 2 inches below the under line of the roof girders, 10 inches outside of the center line of rail of the eastern runway, and 22 inches outside of the center line of rail of the western runway, all on top of runways. No part of the crane or crane mechanism, except hoisting chain and hook and the operating cage with its outfit, must project below the level of top of the crane runways. A space, indicated by letters A B C D, all along the eastern runway must be kept clear at all times, and the trolley must be so arranged that no part of it or of the hoisting mechanism can be brought into this space, even in the most easterly position of the trolley.

No part of the operating cage must come nearer to the floor line of the shop than 11 feet 3 inches. The operating cage should be as small in size as convenience will permit, and it may be located, as indicated in

the drawing, either near the western runway, at E, or between this and the middle of the span of the runways, at F. The crane has to carry gun hoops or jackets up to 5½ feet in diameter at the maximum lift of the chain, and provisions must be made that all parts of the cage are sufficiently to one side of the bridge to clear work of the above diameter lifted up as high as the crane hook will permit.

There will be only one hoist. The several motions of the crane—namely, bridge travel, trolley travel, and hoisting and lowering—are to be effected by separate electric motors, of which there will be three, as follows:

One for the bridge travel, to be located on the bridge.
One for the trolley travel,
One for the hoist,
} to be located on the trolley.

Electric current for operation of the crane will be supplied by the Department at the switch-board of the dynamo room in the gun shop. The contractor will bring the trolley wire to this switch-board and connect them there to the switches provided for. The contractor will also provide an automatic circuit-breaker of approved construction, with proper connections for same, in the connection of the trolley wires with the switch-board.

The trolley wires must be supplied by the contractor on insulated rollers supported on the braces of the western crane runway. They must have sufficient capacity to maintain the potential on the farthest point of the trolley wire with the crane working at its maximum rated capacity. The maximum loss in this case must not exceed a difference between the voltage at the motors and at the dynamo of more than 5 per centum.

The length of the longitudinal travel or of the runways will be 234 feet.

The trolley travel should admit of operating the hoist within the largest possible area of the floor space covered by the crane runways.

In order to prevent over travel in either direction, the crane bridge as well as the trolley must be provided with automatic stops. The speed of the several motions when the current is at its normal potential will be as follows:

Bridge travel, not less than 25 feet nor more than 50 feet per minute.
Trolley travel, about 25 feet per minute.
Main hoist, to hoist a maximum load of 30 gross tons at 6 feet per minute.

The motors for the several operations must be of the following capacity at least:

For the bridge travel, of 10 horse-power.
For the trolley travel, of 5 horse-power.
For the hoist, of 15 horse-power.

In case the construction of the crane requires the application of greater powers than those stated in order to obtain the necessary speeds of bridge, trolley, and hoists with the maximum load, as given above, crane builders will state so in their bids.

Bridge.—The bridge is to consist of two girders made of rolled beams, or they may be of the built-up type of wrought iron or mild steel of such cross-section, depth, and construction as to limit the fiber stress in the upper or compression members of each girder to a maximum of 7,000 pounds per square inch and in the lower or tension members to 8,000 pounds per square inch, net section, when carrying a load equal to the full nominal capacity of the crane at the center of the bridge, and in addition to such load the entire weight of the bridge, trolley, and

connecting parts. The two girders forming the bridge to have such lateral stiffness as to be independent of each other, and the construction of the trolley to be such as to enable the hook and lower sheave or chain-blocks to rise between the girders, thus giving the maximum height of hoist.

The rails supporting the trolley will rest directly over the center of the bridge girders. These rails must be especially heavy and must have a width of not less than 4 inches across the head. The material for girders is to have a tensile strength of not less than 50,000 pounds nor more than 65,000 pounds per square inch, with an elongation of not less than 20 per centum in 8 inches.

The girders will rest directly upon carriages or wheel frames at each end. The connections between these carriages and the girders must be so rigid that racking or getting out of square will be impossible.

The wheels for the longitudinal travel are housed in these frames. Their diameter should not be less than 16 inches, and they must be turned or ground to the same diameter. They must be of proper dimensions and form on tread and flanges to suit the profile of the rail on top of the crane runways, and must be flanged on both sides.

Trolley.—The trolley is to travel directly on top of the bridge, and its construction should enable the hook to reach as close as possible on either side within the clearance lines. It is to be provided with the motors for hoist and trolley travel. The hoisting chains should lead practically in a vertical line from the chain sheaves in the bottom block when this block is in its highest position. The chain drum or drums will be turned and grooves cut from the solid metal. The grooves must be of ample pitch to prevent wear and tear of coils while winding, and to be of such depth that the vertical links of the chain will bear on the bottom of the grooves, while the horizontal ones will bear on the face of the drum. Their arrangement will be such that the load will be always suspended from the center of the trolley and the weight of load and trolley will at all times be sustained equally by each girder. No overlapping of the chains will be permitted at any time.

The trolley is to have steel side frames and is to be carried on 4 track wheels of cast steel of not less than 12 inches diameter, turned or ground to a uniform size, and having a face of such width as to run on rail having not less than 4 inches width across the head.

Hoisting chains, etc.—The chain blocks are to give a practically vertical lift throughout.

The hoisting chains must be of special quality. Tensile strength to be 52,000 pounds per square inch, elongation to be 15 per cent, and contraction at point of fracture 20 per cent. Links to be as short as possible.

The operating cage is to be suspended to one side of the southern main girder within the limits indicated, and is to allow the full travel of trolley and of the hook, carrying in its highest position work of 66 inches diameter within a distance of 2 feet between center of hook and western runway and 3½ feet between center of hook and eastern runway.

All manipulating levers must be grouped entirely on the operating cage. They should be as few as possible and arranged in such a manner as to prevent confusion. The electric outfit of the cage must include a voltmeter and an ammeter of approved dead-beat standard type, suitably connected and properly located so that the operator may at any moment observe the condition of the current.

All necessary rheostats, reversing switches, fuse boxes, and main

switch, together with all the necessary apparatus for controlling each and every motion of the crane (which must be entirely independent of each other) must be furnished and suitably arranged.

Automatic brakes.—The hoisting train will be fitted with an automatic magnetic brake operated through the means of solenoids, so that "racing" or accidental running down of the load will be impossible except from breakage of parts between the brakes and the load. These brakes will be entirely automatic, and will not require any manipulation on the part of the operator.

Motors.—The motors are to be of the water-proof type with steel casings forming the fields of the motor. The armature-driving pinion and the gear into which it meshes are to be incased in a brass casing, which is filled with oil. This type of motor is practically noiseless in its operation. All motors are to be flexibly hung in position with self-oiling bearings. They should be of the flat-field type, having wrought-iron fiel ls with self-oiling boxes. All loose running bearings must be bronze-bushed.

Attention should be given that spare parts to be kept may be interchangeable for as many motors as possible.

Rheostats.—They are to be fitted with Elihu Thomson's patent blow-out magnet for blowing out the sparks where the break is made, in order to avoid kicking in the fields, causing burning where break is made.

Gears, bearings, clutches, lubrication, etc.—All gears throughout the crane are to have accurately cut teeth. excepting the main master-wheels (attached to the chain-drums) and the pinions gearing into the same, which shall be shrouded. Pinions of less than 30 teeth must be made of forged steel.

The most careful provisions must be made for continuous and thorough lubrication of all journals and bearings, and great care will be taken to reduce the friction of the mechanism and produce a machine of highest efficiency.

No clutches, worm gears, or miter gears are to be used, therefore, in the construction.

All parts of the crane mechanism must be of easy access for repairs.

Painting.—All parts to be neatly painted, excepting the bright or finished pa ts, and these to be slushed.

Drawings.—Bidders will submit with their proposals drawings of the crane which they propose to furnish. Bidders will be furnished with drawings on application, showing the position and dimensions of the crane supports. All drawings necessary for the design, construction, erection, and operation of the crane will be provided and paid for by the contractor, who, at the completion of the work, will furnish the Ordnance Department with a complete set of working drawings, or prints, of the crane and its appurtenances.

Weights of different parts.—Bidders will furnish a clear and detailed statement of the weights of the different parts of the crane proposed, also the maximum load, which, under certain conditions is likely to fall on the track wheels.

Delivery.—The contractor is to deliver the crane and all its parts complete, so as to be in working order when resting on the runways and connected to the switch-board, in the gun factory building at the Watervliet Arsenal, West Troy, N. Y. He is also to erect said crane on runways in complete working order by his own employés and under his own superintendence.

Railroad tracks, connecting with the tracks of the Delaware and Hudson Canal Company, run into the building, and the existing 120-ton crane may be used by the contractor to transport heavy parts of the crane from the cars to within a short distance of the place of erection, as far as this does not interfere with the operations at the gun factory.

The contractor will furnish all material and all skilled and unskilled labor and superintendence necessary for the delivery of the crane on the floor of the factory and for the erection of the same on the runways and its starting. He has to comply with the State and other laws, and will be solely responsible for any injury to life and limb of his employés, or for any damage done to Government property by his employés.

No labor or material of any description will be furnished by the Ordnance Department.

Time to complete the work and forfeitures for delay.—The bidders will state the time within which they will deliver the crane with all its appurtenances at the place mentioned above, and also the time for erecting the crane on the runways in complete working order, from the date of the award of the contract.

For any delay in the completion of the crane beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price, the sum of $20 for each and every day (excepting Sundays) after said date until the completion of the contract.

Payment under the contract.—Payment will be made upon final acceptance of the crane by the United States after a satisfactory trial during fifteen consecutive working days, if practicable, with loads not exceeding the maximum.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, United States Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

SPECIFICATIONS FOR ONE 2-HORSE-POWER AND ONE 5-HORSE-POWER ELECTRIC MOTOR.

These motors are to be constructed for a current of 220 volts. They should be of water-proof type, and all parts, except the belt-pulley on the armature shaft or on the back-gear shaft (if the motors are back-geared) are to be inclosed in a metallic frame or housing, whose parts are hinged together in such a manner as to afford easy access, when necessary, to the interior parts of the motors. Armature pinions and gears are to be inclosed in an oil and dust-proof metal case, partly filled with heavy grease, and proper provisions are to be made for a thorough lubrication of all running parts.

Inasmuch as these motors are intended primarily for experimental purposes, each motor is to be mounted on a portable frame, so as to move it without great difficulty from place to place.

Each motor is to have a belt pulley for the transmission of power, and each one must be provided with a switch and with a rheostat of proper capacity and approved construction.

Each motor must be furnished with a cut-out.

One Thomson recording watt meter will be furnished, applicable for the power circuit of either motor, and of not less than 100 amperes.

Bidders will furnish a complete description of their motors and state the price of each motor, delivered in complete running order in the gun factory at the Watervliet Arsenal, West Troy, N. Y. They will also state the time of delivery from the date of award.

SPECIFICATIONS FOR ONE PORTABLE PLATFORM SCALE FOR WEIGHING GUNS UP TO 300,000 POUNDS.

This scale is to consist of a substantial frame and platform of wrought iron or steel. The members of frame and platform must be properly planed and fitted at their junctions, and bolts must be turned to the extent necessary to secure good joints. The platform is to be 12 feet wide by 15 feet long, and is to have a floor of heavy planking on top. This planking, the supports for the scale pillars, and the shelf for the beams-stands are the only parts which may be made of wood.

The frame is to be supported on 8 heavy cast-iron wheels, 4 on each side, of not less than 20 inches diameter and not less than 6 inches face. These wheels are not to be flanged, as they are intended to run on the floor of the shop. Each wheel must be mounted on a short axle with a bearing on each side of the wheel of not less than 4 inches diameter and 6 inches length. Directly on top of these bearings are to rest the beams forming the frame. The gauge of the wheels from center to center of tread is to be about 9½ feet. The platform is to carry on top 4 supports of timber of heavy dimensions for the reception of guns. These supports must be shaped out properly (V-shaped or circular) to receive guns of a maximum diameter of 5½ feet. Each block is to be reënforced properly with heavy truss-rods. These blocks should rest as near as practicable over the wheel-bearings.

The scale is not intended to be propelled with a gun placed upon it, but it is to be run under a crane, which will place the gun upon it. After weighing the gun will be removed, and the scale will be pushed or run to a place designated for this purpose. The scale must be made very substantially and carefully in a first class manner in every respect.

The construction of all parts of the scale mechanism proper must be equal to the standard of Fairbanks or other manufacturers of established reputation.

Bidders will submit a drawing of the scale which they propose to furnish and then will state the time of delivery from the date of award. The scale is to be delivered in complete working order on the floor of the gun shop at the Watervliet Arsenal, West Troy, N. Y.

Payment will be made after a satisfactory test of the scale.

(4772–'93.)

APPENDIX 26.

REPORT OF THE PRINCIPAL OPERATIONS AT ROCK ISLAND ARSENAL DURING THE FISCAL YEAR ENDED JUNE 30, 1893; COL. A. R. BUFFINGTON, COMMANDING.

(4 plates.)

ROCK ISLAND ARSENAL,
Rock Island, Ill., June 22, 1893.

SIR: In accordance with your instructions, I have the honor to submit the following description of the construction and mode of manufacture of powder cases for storing cartridges for B. L. rifles and mortars:

HEAD.

Cast brass or bronze skeleton head frame, with square screw thread, 3 threads to the inch, cut on the face of the rim. The two hinged handles, when not in use, drop into two recesses below the top surface of the head, thus not interfering with the packing of the cases on top of each other, end to end or side on side. The placing of the handles on top permits rolling the cases when necessary. The head may be screwed in or out by these handles alone or by means of a bar passed through the handles. The powder cases may be lifted and carried either directly by handles or on a bar passing through handles and resting on the shoulders of the carriers.

At the center of the bottom of the head of the 8 inch B. L. powder case is cast a projecting hub with shoulder washer riveted on so as to attach the zinc disks, through the journal thus formed, to the head frame. For the other powder cases these disks are attached to bottom of head by a single pin, with shoulder head, riveted at top.

These constructions permit the zinc disk to remain stationary when the packing ring is pressed hard against the projecting edge of the ring frame, while the rest of the head revolves in screwing down tight, thus making an air-tight joint between the head and body.

The zinc disks consist of two plates $\frac{8}{100}$ inch thick. The rim of the upper and larger one is pressed up so as to form a recess for the packing ring. When the packing ring is laid into the recess the two zinc plates are riveted together with copper rivets, making the two zinc plates and packing ring complete in one piece.

PACKING RING.

Copper in one piece without joint and turned true to fit the recess between the zinc plates.

RING FRAME,

into which the head is screwed, is made of cast brass and fitted into the top of cylinder and soldered, about one-third of its width projecting above and even with outside, so that the top band, $\frac{8}{100}$ by $1\frac{3}{4}$ inches, is soldered firmly to both zinc and brass.

CYLINDER.

Sheet zinc, $\frac{8}{100}$ inch thick, formed round, with edges scarfed off to make an even joint when soldered together. The inside lining is made of straw board paper $\frac{1}{16}$ inch thick, wound on a wooden cylinder five times round and finished to $\frac{5}{16}$ inch thick. As the cylinder revolves the contact face of the paper is kept spread with glue and a heavy cast-iron roll revolves on top, securely pressing and smoothing the surface. After drying and cutting to length, the paper roll is inserted into the zinc cylinder and there painted with two coats of lampblack and oil.

BOTTOM.

Wood disk, $\frac{5}{8}$ inch thick, the upper face covered with paper $\frac{1}{16}$ inch thick, and upper side rabbeted and projecting partly up inside of lining and partly under the lining to the outside cylinder. The zinc bottom is soldered in even with bottom of cylinder. A zinc band, $2\frac{1}{8}$ inches by $\frac{8}{100}$ inch, is formed around, folded under the bottom, firmly soldered, and then put into a lathe and scraped smooth.

Dimensions of service powder cases.

Piece.	Charge.	External diameter.[1]	External length.	Internal diameter.	Internal length.	Internal capacity.	No. of charges per case.
	Pounds.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	
8-inch B. L. rifle	125 to 130	10.57	26.83	9.625	24.875	65	$\frac{1}{2}$
10-inch B. L. rifle	250 to 260	12.82	30.075	11.875	28.125	130	$\frac{1}{3}$
12-inch B. L. rifle	450	15.445	24.95	14.5	23.0	150	$\frac{1}{3}$
12-inch B. L. mortar (steel)	105 to 110	13.82	26.95	12.875	25.0	[2]125	.....
12-inch B. L. mortar (cast iron, hooped).	[3]80	.....	.....	.....	.....	.....	1
	[3]58	.....	.....	.....	.....	.....	2
	[4]33	.....	.....	.....	.....	.....	3
	[4]25	.....	.....	.....	.....	.....	4
	[5]18	.....	.....	.....	.....	.....	6

[1] Over all.

[2] The cases for mortar powder may be filled with cartridges as follows: One 110 pounds, or one 80 pounds and one 40 pounds, or two 58 pounds, or three 33 pounds, or four 25 pounds, or six 18 pounds.

[3] Brown prismatic powder.

[4] Black prismatic powder.

[5] Black hexagonal powder.

DESCRIPTION OF 100 ZINC POWDER CASES MADE APRIL 26, 1886.

HEAD.

Cast brass skeleton head, with four arms; rim screwed in same as new model. The copper rod ($\frac{5}{8}$ inch diameter) bails hinged to ears that are riveted to arms of head. The zinc disk attached to head is cast in one piece and the groove for packing ring turned out. The zinc disk is soldered to lower flange of pivot pin, passing through center hub of arms and freely revolving in it.

PACKING RING.

Pure soft rubber ring, solid and endless, without joint or seam. Inner diameter 12 inches; cross section $\frac{2}{16}$ by $\frac{3}{16}$ inch.

RING FRAME.

Same as new model, except the wedged part projecting upon the straw board lining, which in the new model has been lengthened to facilitate extraction of cartridge when the case is on its side.

CYLINDER.

Same as new model, except sheet zinc $\frac{5}{100}$ inch thick was used for body and bands.

BOTTOM.

Same as new model ($\frac{8}{100}$ inch thick zinc).

Dimensions.

	Inches.
Inside diameter	13.375
Inside depth	25.0
Exterior diameter (over all)	14.2
Exterior length (over all)	27.5

Very respectfully, your obedient servant,

JNO. T. THOMPSON,
First Lieutenant, Ord. Dept., U. S. Army.

The COMMANDING OFFICER.
(3379–'93.)

ROCK ISLAND ARSENAL,
Rock Island, Ill., June 30, 1893.

SIR: I have the honor to submit the following report of the principal operations at this arsenal, exclusive of fabrications in the shops, for the present fiscal year:

REPAIRS AND RECONSTRUCTION OF THE FLOOR SYSTEMS OF THE ROCK ISLAND BRIDGES.

An examination of the Rock Island bridges showed the wooden and iron joists of the wagon floors to be more or less decayed and unserviceable, as detailed in a special report from this arsenal dated March 21, 1892.

The metal work on both bridges, except portal bracing on the wagon bridge, was done by contract, the woodwork and said bracing by arsenal employés. After advertisement, contract was awarded, September 23, 1892, to the Carnegie Steel Company (Keystone Bridge Company), work to commence November 15, 1892, to be finished January 15, 1893. After much delay, owing to nonreceipt of the steel, work was commenced December 20, 1892, on the Rock Island bridge and finished on both bridges January 22, 1893. The work was much delayed by the severity of the cold and stormy weather, the temperature for nine days being below zero, and the average temperature for the whole time, as recorded at bridge, 10.6° above.

I. THE ROCK ISLAND BRIDGE.

This bridge, of double quadrangular pattern, consists of one draw span, 370 feet long, and five fixed spans (two of 260 feet and three of 220 feet long), with two decks. The upper is a railroad iron deck, supported half way on the vertical posts, and the lower is a wagon deck, which includes a double street-railway track and two footways, supported on double 12-inch channels in the lower chord.

The repair consisted in the replacing of the 740 wooden floor joists in the bridge by 482 10-inch steel I-beams, 99 pounds per yard, and the construction of a wooden floor system thereon. These beams are of a grade known as low steel, of a tensile strength of not less than 60,000 pounds, or more than 68,000 pounds per square inch, an elastic limit of not less than five-eighths of ultimate strength and an elongation in 8 inches of not less than 22 per cent.

In the fixed spans every beam (27 feet 11 inches long, except five short ones) is placed perpendicular to the axis of the bridge (about 3 feet 4 inches from center to center of adjacent beams), and is supported on each side of the bridge by a rocker plate, which rests on top of the channel bars in the lower chord. The beam is attached at these points of rest by a half-inch bolt passing through two holes cut in its lower flange and down between the lower-chord channel bars. These beams are so arranged that they project alternately on one side and then on the other some 8 feet beyond the lower chord, so as to form the supports for the foot-walks.

The 10-inch steel I-beams on the draw span are of two sizes (with one exception), 35 feet 8 inches long and 20 feet 2 inches long, placed alternately, the longer beam projecting beyond lower chord on each side for foot-walk supports. These beams are placed and spaced similarly to those on fixed spans, but are differently fastened to the lower chord. Each beam is set on each side of the bridge on a rocker chair, about 7 inches high, resting on the lower chord. These chairs on the same lower chord of each panel are connected by a strap iron three-eighths of an inch by 4 inches by length of panel, placed on top of the chairs, bolts passing through the flange of each I-beam, the strap and the top flange of each chair locking these parts together at each of these points.

The steel girder rails of the street-car company are held by low steel shoes slipped over the upper flanges of the I-beams. The arsenal carpenters followed the ironwork in both bridges as fast as laid with a strong oak-and-pine floor system that will admit of the bridge being repaired hereafter without interruption of traffic.

II. THE ROCK ISLAND WAGON BRIDGE.

This bridge is of the double quadrangular pattern, consisting of four spans of about 150 feet each, thirteen panels to a span. Before repair, it had double floor, 15-inch iron I-beams of 125 pounds per yard, fastened by bolts and separators, suspended on hanger bolts from each panel point, except at the span ends, the floor beams and brackets at these points being sufficiently strong for support of new floor system.

The 15-inch double iron I-beams were removed and 15-inch double-steel I-beams of 150 pounds per yard (31 feet 7 inches long) substituted; at the same time the cast-iron filling plates between the beams and the supporting hanger plates were removed and replaced by cast-iron rocker plates to distribute the load equally on the hanger bolts.

All new metal work was painted two coats of metallic paint prepared with boiled linseed oil. Larger and stronger portal braces, made in the arsenal, have been placed on spans of this bridge.

The hand-power machinery for raising the decks of the draw span on the Rock Island bridge to a level with the roadways when closing the draw is slow and laborious in operation. This machinery is to be replaced by quicker acting hydraulic jacks, operated by the pumps that furnish the power for moving the draw.

When this is done, the lower chord bars repacked—decided to be impracticable at the time the old wagon floor was replaced—and iron chord pins replaced by steel pins now deemed necessary for the safety of the bridge, altogether a work of considerable magnitude and cost, the repairs on this bridge will be completed.

Abstract of travel over Rock Island bridge during year.

	North.	South.
Engines with trains	11,278	11,307
Engines without trains	513	499
Total	11,791	11,806
Passenger cars	19,367	19,330
Freight cars	137,088	135,732
Foot passengers	239,352	242,979
Teams	197,068	195,643
Steamboats	1,410	1,490
Barges	449	407
Rafts	.....	741

The iron guard rail fence on Fort Armstrong avenue is being extended from the causeway, where left off, to the Rock Island bridge, being placed further from curb than old wooden fence, so as to allow widening the sidewalk.

III. THE CANAL BRIDGE.

Minor repairs have been made from time to time on this bridge, but its slight structure is unequal to the heavy and continuous traffic now passing over it, due to the establishment of rock-breaking mill on Sylvan Island.

IV. ROCK ISLAND ARSENAL RAILROAD.

The single main track has been extended about half a mile around the east end of the lines of shops to a point about 120 feet beyond the west end of storehouse K, thus making the second of the storehouses and this part of the armory row of shops more convenient for large rail shipments. The curve has a radius of 491 feet, and the grades, including the approach to the storehouse, are easy. The track is laid with a 56-pound-per-yard steel rail, with Sampson angle joints and standard oak ties, with rock ballast and cinder topping.

V. STOREHOUSE K AND SHOP K.

The storehouse is now completed and in use. The steps and platforms on the usual foundations were constructed on the north and west sides and in the court of shop K.

VI. MISCELLANEOUS WORK.

The concrete walks and the ramps on the north side of storehouse K were laid and the grounds graded. The cement and brick lining of the interior of the main stone reservoir has been repaired. New shingle roofs, painted, have been placed on the main and small reservoirs. During the late autumn and early spring the surface of the island was thoroughly burned, destroying the dead grass, branches, and other accumulation. The soft trees planted alternately with the elms and other hard trees for shade have been generally removed along the avenues and in front of shops.

The earthen dike on Sylvan Island, at the junction of the stone-cored part with simple earth part, leaked considerably at high water this spring and was temporarily repaired.

VII. WORK ADDITIONAL TO FABRICATIONS IN THE SHOPS.

The 13-ton steam hammer, transferred from the National Armory, Springfield, Mass., for the manufacture of 3.2-inch field-gun carriages, has been set up in the forging and blacksmith shop, connected with the present steam plant of the arsenal by the requisite piping, and provided with a heating furnace. This work, in connection with the overhead system of draft and heating for this shop, has been of some magnitude, as has also been the work in the other shops in placing old and new machinery and arranging for shop room for the additional work now being and to be done at this arsenal.

VIII. SHIPMENTS OF ORDNANCE AND ORDNANCE STORES.

	Number.	Quantity.
		Pounds.
Issues	1,445	1,377,769
Receipts	402	1,056,609
Total	1,847	2,434,378

Very respectfully, your obedient servant,

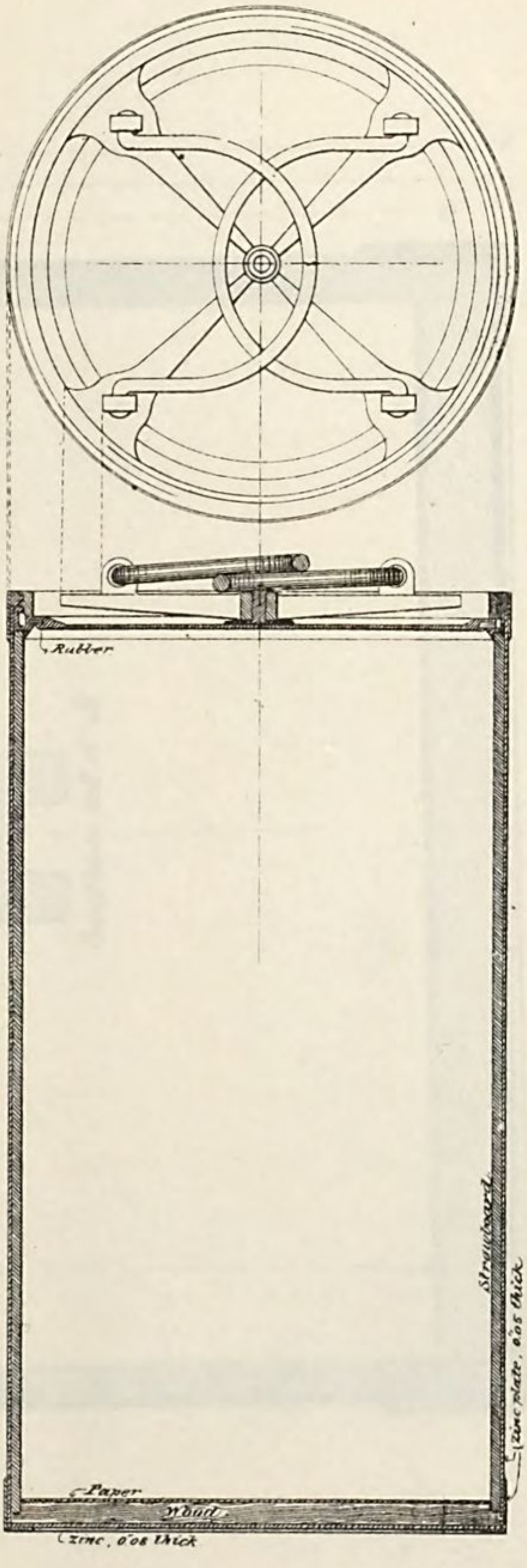
JNO. T. THOMPSON,
First Lieutenant, Ord. Dept., U. S. Army, in Charge.

The COMMANDING OFFICER.

(3865–'93.)

Metallic Powder Case.

Manufactured at Rock Island Arsenal in 1886.

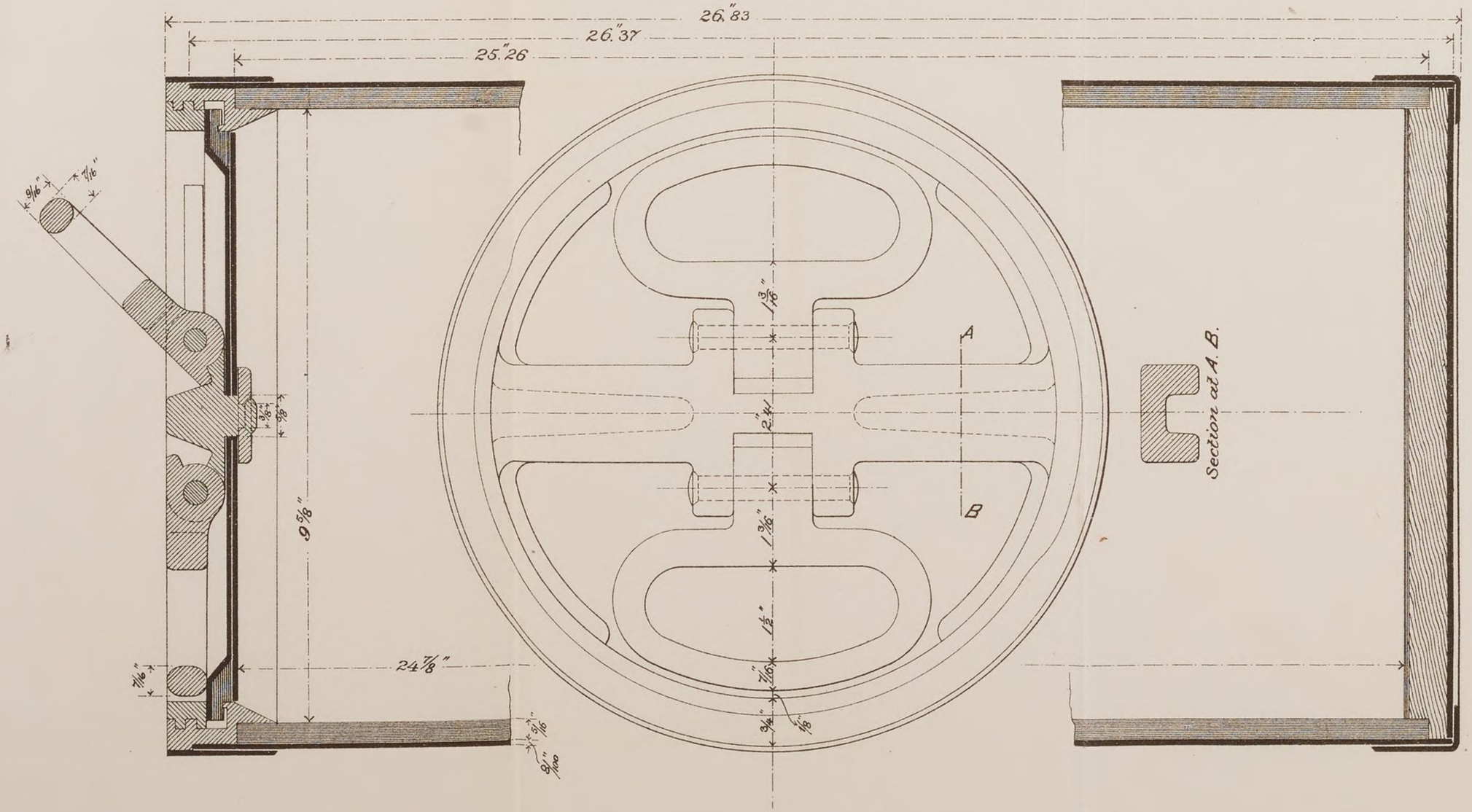


Scale:

0 1 2 3 4 5 6 7 8 9 10 *Ins.*

Powder Case for 8 Inch B. L. Rifle, Steel.

Scale: Full Size.



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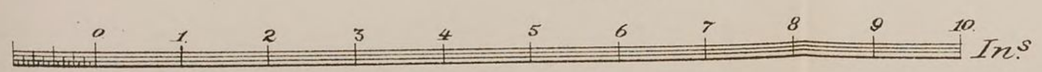
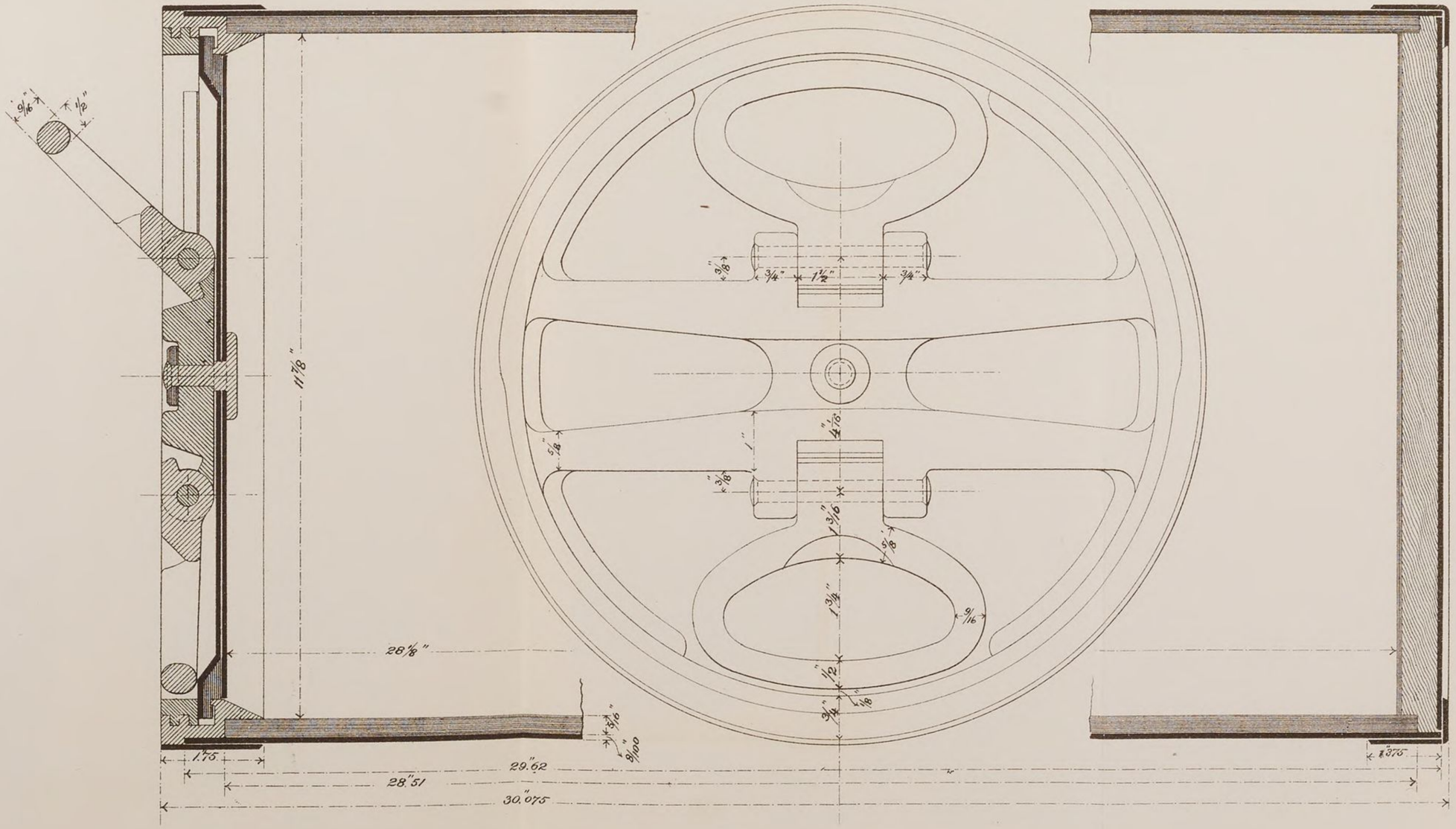
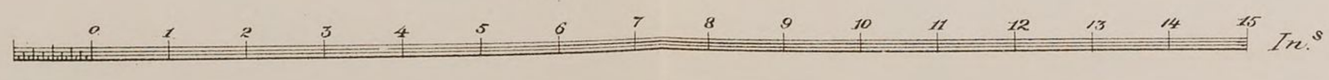


Powder Case for 10 Inch B.L. Rifle, Steel.

Scale: Full Size.

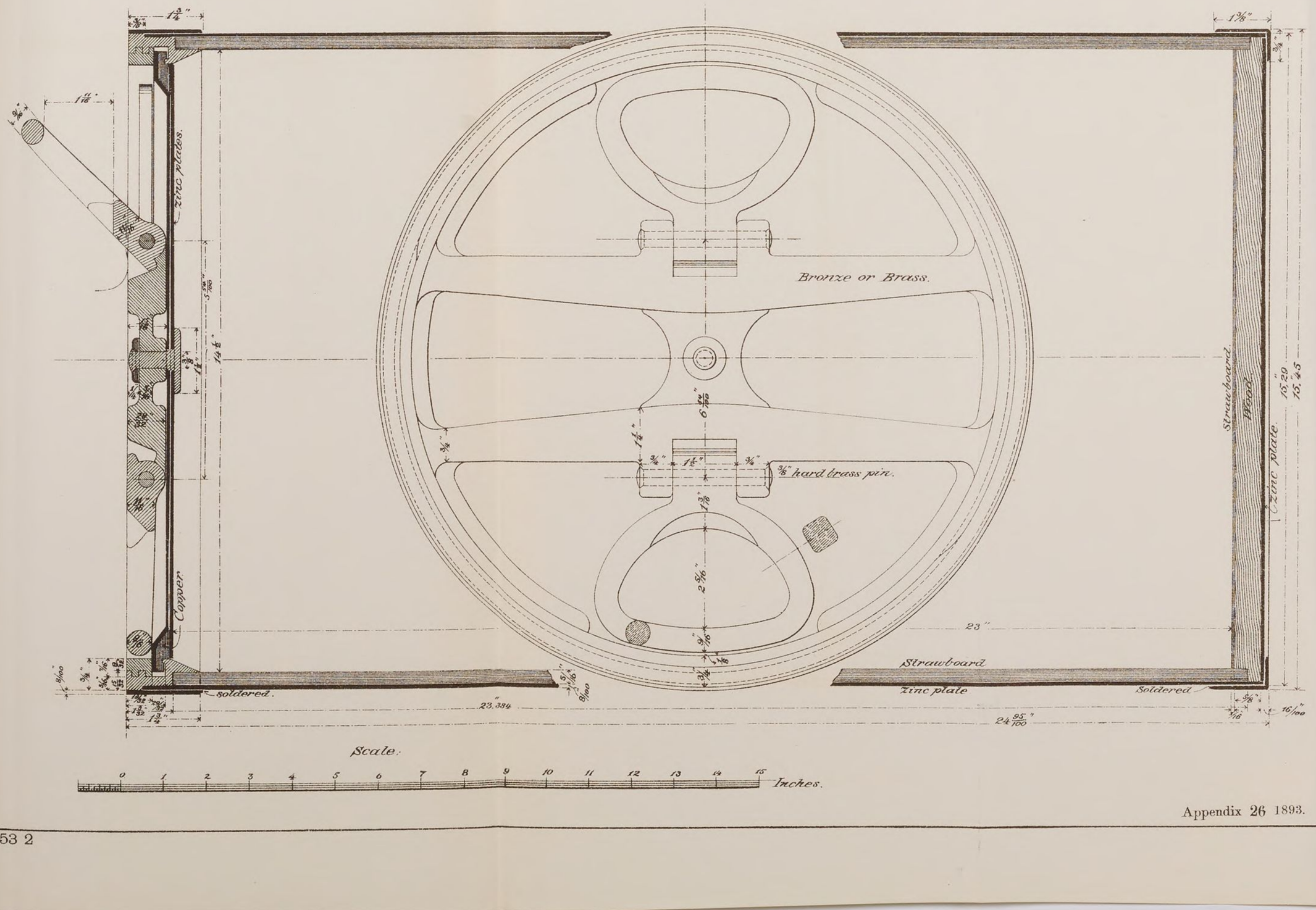


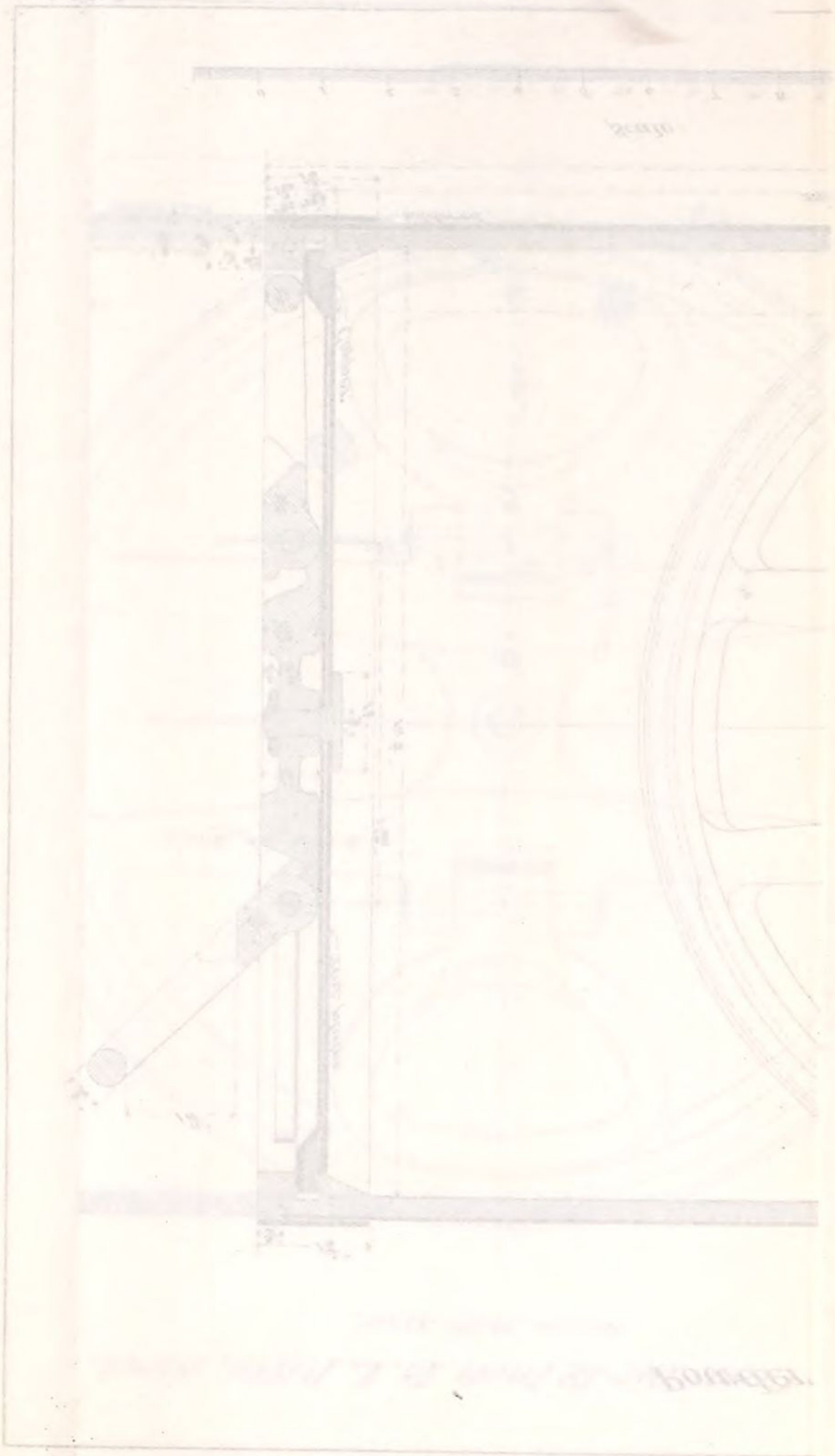
Scale.



Powder Case for 12 Inch B. L. Rifle, Steel.

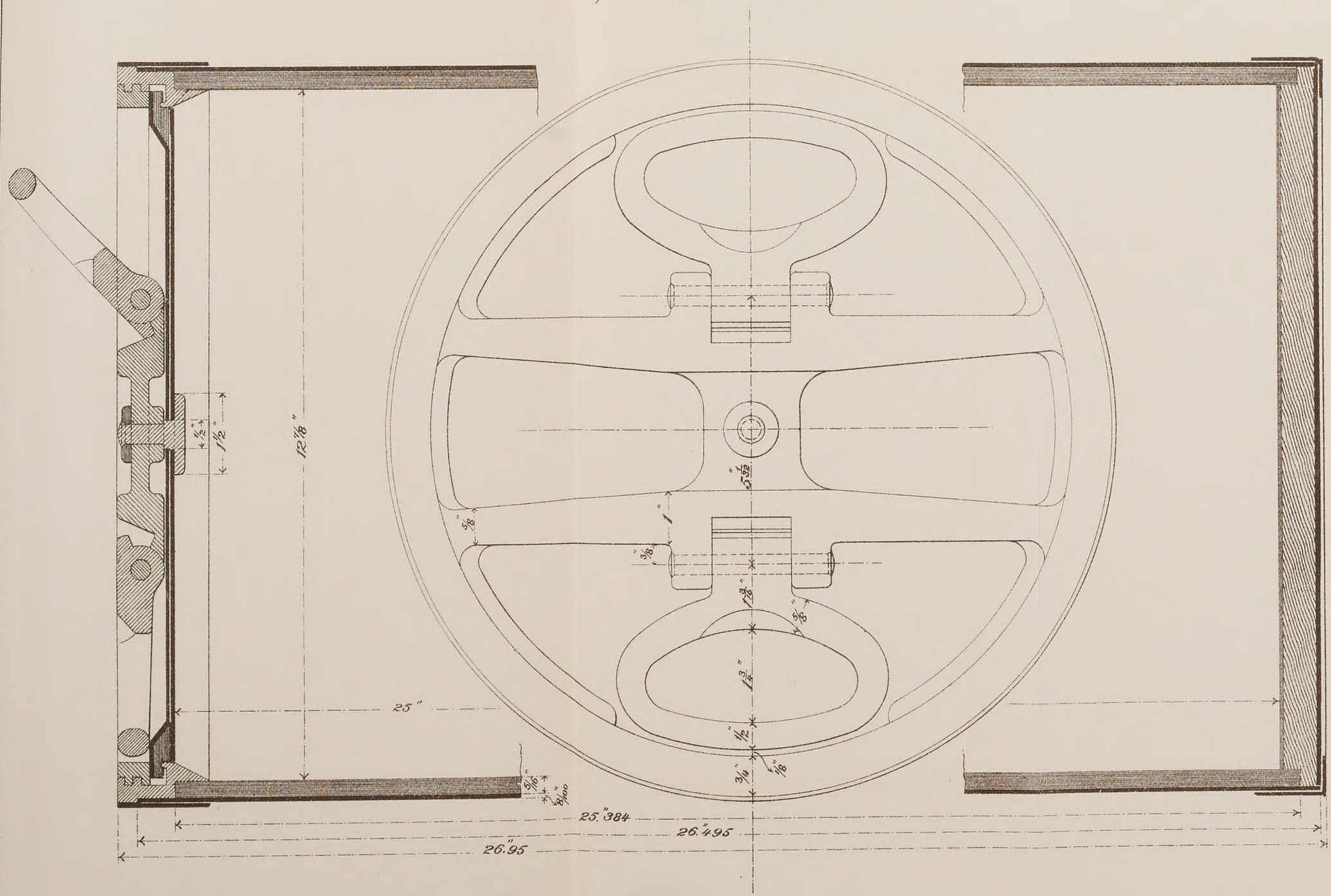
Scale: Full Size.





Powder Case for 12 Inch B.L. Mortar, Steel.

Scale: Natural size.



Note: Handles are the same as in Case for 10 In. B. L. Rifle, Steel.

Scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 *Ins.*

APPENDIX 27.

ANNUAL REPORT OF PRINCIPAL OPERATIONS AT THE WATERTOWN ARSENAL.

(5 plates.)

The principal work done at this arsenal during the fiscal year ending June 30, 1893, has been as follows, viz:

In the enlargement and improvement of the gun-carriage plant by the erection of new shops, the enlargement, alteration, and repair of old shops, and the purchase of new and improved machine tools.

The fortification bill, approved July 23, 1892, contained the following items: For the enlargement and improvement of the heavy gun-carriage plant at Watertown Arsenal, $151,000; for fitting up new carpenter and pattern shop, moving and setting up machinery and shafting, including new machines required, $9,400.

The following machine tools have been contracted for from these appropriations and are either already set up or are about ready to be set up:

List of machine tools, etc., purchased and contracted for during the fiscal year ended June 30, 1893.

Machine and erecting shop:	
1 10-foot vertical turning and boring mill	$3,980.00
1 5-foot vertical turning and boring mill	3,140.00
1 11-foot by 8-foot by 24-foot open-side extension planer	13,990.00
1 6-foot by 6-foot by 20-foot planer	7,875.00
1 horizontal drilling and milling machine	11,325.00
1 slotting machine, 18-inch	1,995.00
1 slotting machine, 12-inch	1,250.00
1 lathe, 48-inch, with boring attachment	4,790.00
2 lathes, 42-inch by 15-foot centers	5,360.00
1 lathe, 36-inch by 15-foot centers	1,570.00
1 lathe, "rivet" bench	450.00
1 upright drill, 50-inch	1,800.00
1 upright drill, 36-inch	1,050.00
1 upright drill, 30-inch	750.00
1 vertical spindle milling machine	2,850.00
2 Universal milling machines, heavy	3,200.00
1 Universal milling machine, No. 3	925.00
1 vertical spindle milling machine	970.00
1 gear cutter, 72-inch	3,300.00
1 gear cutter, 48-inch	1,500.00
1 Universal grinding machine	1,485.00
1 Universal tool grinder	700.00
1 Universal drill grinder	220.00
1 cutter and reamer grinder	205.00
Wood-working:	
1 buzz planer, 20-inch by 7-foot table	155.25
1 surface planer, 20-inch	232.88
1 Daniels planer, 27-inch by 25-foot	627.00
1 Daniels planer, small, tilting	336.95

Wood-working—Continued.	
1 vertical cut-off saw, 40-inch	$372.60
1 rip saw, bench, 36-inch	331.20
1 combined mortising and boring machine	580.00
1 Universal post-boring machine	62.10
1 Universal horizontal-boring machine	351.00
1 large face-plate lathe, 72-inch swing	207.00
1 small face-plate lathe	103.50
2 pattern-makers' lathes, 24-inch swing (15-foot and 6-foot)	535.90
2 band saws, 40-inch wheel	217.35
1 hand-boring machine	5.00
3 20-ton traveling cranes	6,654.20
1 Sturtevant blower, No. 8	337.50
1 crane ladle, 10-ton	200.00
1 crane ladle, 8-ton	150.00
1 crane ladle, 2¼-ton	62.94
1 crane ladle, 1-ton	44.82
4 shank ladles	28.00
Blacksmith shop: 1 Sturtevant blower, No. 9	487.50

There remain some machine tools yet to be purchased to properly equip the shops, but the appropriation for the new fiscal year will provide means for the purchase of most of them.

In accordance with the approved plans of the Chief of Ordnance, work has progressed during the fiscal year in the alteration and enlargement of old shops and storehouses and in the building of new shops as follows:

The foundry building has been extended about 110 feet in length, bringing its western end on a line with the ends of the other machine shops.

This extension is fitted up as a machine shop with a Yale & Towne 20-ton traveling crane, and certain large planers, horizontal-boring mills, vertical-boring and turning mills, slotters, etc., and has ready access to the foundry by means of a railroad track through an 18-foot door.

A Yale & Towne crane of 20 tons capacity has also been put in the foundry, a new core oven of capacity sufficiently large for our largest castings has been built, and with the removal of the 16-foot boring mill from its present site in the foundry to the south wing of the machine shop the foundry may be considered completed. The additions mentioned will double its capacity and provide the Department with a complete and extensive foundry.

The south wing of the machine shop has had its first and second floors removed and its cellar filled up to the level of the ground. A 20-ton Yale & Towne traveling crane has been erected here also. This wing has connection with the foundry through an 18-foot door in its south side by means of a railroad track.

Castings can thus be readily put upon cars by the foundry crane and transported by rail to either the foundry-extension machine shop or the south-wing machine shop, where they can be taken up by the traveling cranes and put upon the machine tools to be finished.

As our castings of both steel and iron are large and require little moving while being finished, it is believed that these cranes will answer all needs, at least for the present.

This south wing is fitted up with the largest tools, such as the 11-foot by 8-foot extension planer, the large boring mills, both horizontal and vertical, slotting, etc.

Railroad tracks connect both the foundry extension and the south wing with the new erecting shop.

The erecting shop is being built on a line parallel to the west ends of the machine shops and 45 feet distant from them. It is about 280

feet in length, 80 feet wide, and 25 feet high to the cornice. Brick piers are built in the walls for a traveling crane, and a railroad track connecting with the Fitchburg Railroad runs through its northern end to the middle of the building.

For the present the south end of this building will be used as an erecting shop, the northern end for the storage and shipment of completed carriages.

The storehouse on the northwest corner of the old arsenal inclosure has been converted into a complete carpenter and pattern-maker's shop by removing the second-story floor, thus giving overhead room for shafting and plenty of light, and by building an L addition for an engine room, tool room, and foreman's office. An engine of 80 horse-power supplied with steam from the main battery of boilers at the machine shops affords ample power.

The type 8-inch B. L. barbette carriage has been completed, and, after trial at Sandy Hook, is now on exhibition at the World's Columbian Exposition. Our present orders contemplate the manufacture of seven more of these carriages, and work is steadily progressing on them. It is believed that all of these will be ready for issue by the spring of 1894.

The type 12-inch B. L. barbette carriage has been delayed in its completion by the failure of the steel companies to furnish proper steel castings, as well as by the fact that our old tools were inadequate in strength and size to the work required on the castings. The new machines will be in place before fall of this year, and the type carriage will be ready for issue soon thereafter. We have orders on hand for four of these carriages.

We have also orders for five 10-inch B. L. barbette carriages, but the design of these is not yet complete.

In addition to the foregoing our orders cover the manufacture of two 12-inch gun-lift carriages.

Work has progressed in the alteration of 15-inch smooth-bore gun carriages, to adapt them to increased charges for the guns; and also work upon the alteration of the 10-inch smooth-bore carriages and their adaptation to the service of 8-inch converted rifles.

The completion of this year's quota of these carriages during the fiscal year was hindered by the improvements and alterations in the shops, which necessitated the discontinuance of the setting-up shop until the new one is completed. They will, however, be ready for issue in about three months.

The manufacture of shot and shell of 12-inch, 10-inch and 8-inch calibers has progressed very satisfactorily. It has not been necessary to reject one out of some nine hundred manufactured.

With the disestablishment of the projectile foundry at Watervliet Arsenal, and the transfer of all foundry work to this arsenal, our foundry will have, together with its work on gun carriages, sufficient work to keep it steadily employed with all of its enlargements and improved facilities.

In addition to the work on gun carriages and shot and shell, our shops have been employed to quite an extent during the year in the manufacture of implements and equipments for the seacoast fortifications, including gun lifts, siege and garrison gins, artillery targets, platforms for mortars, blocks and tackle, rammers and sponges, etc.

The condition of the Charles River, which borders this arsenal reservation, is receiving the serious consideration of the cities and towns along its banks. For a number of years it has been but a sewer for

these places, until it has become very offensive and injurious to the health of all within reach of its foul odors. A commission has been appointed by the State to consider plans for remedying the evil, and the General Government should lend its aid.

Again, as all of our modern gun carriages are too large to be transported by rail, the navigation of the Charles River is essential to the effectiveness of this arsenal as a point of supplies. Any plans looking towards impeding navigation by bridges or otherwise by railroad companies ought, therefore, to be considered from this point of view.

The work of the testing department during the past fiscal year has been upon the regular inspection of material for ordnance purposes, which has included material representing work under contract and the product of the arsenal foundry.

Work has been continued in the class of investigative tests, wherein the physical properties of different kinds of constructive material are investigated, their tensile values ascertained and endurance under long-continued repeated stresses.

Chemical analyses have been made of all the important material tested, which fact taken in connection with the thorough manner in which the physical tests are carried out makes the results of great present and also of permanent value for future reference.

The testing machine has been called upon to make an unusually large number of tests for private parties who, by an act of Congress, are permitted to have tests made upon defraying the cost of the same. These tests are, for the most part, addressed to important objects, and the dissemination of this information must have a very beneficial influence on the industries represented.

Among the investigative tests deserving special mention is the test of a section of an 8-inch tube by hydrostatic pressure. In the exhaustive investigation of the elastic properties of this tube the first stage of the testing has been completed, namely, the test with interior pressure unaccompanied by longitudinal stresses. The actual expansion of exterior diameter has been ascertained and the ratio of longitudinal contraction to diametrical expansion has been determined.

This ratio has also been determined on plain tension bars, and from these results, which are in harmony, it appears that the commonly accepted ratio will be modified somewhat, the longitudinal contraction being found less in amount than expected.

Some special tests of large specimens of their class were made and the fractured material sent to the ordnance section of the World's Columbian Exposition, Chicago, Ill.

Some striking results were shown in the tests of brick piers illustrating how it is possible to add largely to the strength aud rigidity of brick masonry, according to the manner of laying the brick and the kind of mortar employed.

An extensive series of automatic car-coupler tests has been made. This material was collected and submitted for test by the Master Car Builders' Association, whose members represent all the principal railroads of the country, and who are acting in conformity with the views of the Interstate Commerce Commission in the selection and adoption of a suitable car-coupler to meet the requirements of law.

The employment of the testing machine on a subject of such national importance as a safe and reliable car-coupler seems to be most befitting.

Material has been procured for a thorough investigation of the tempering properties of steels, and it is expected this inquiry will lead to

important practical results and furnish definite information on a subject admittedly obscure.

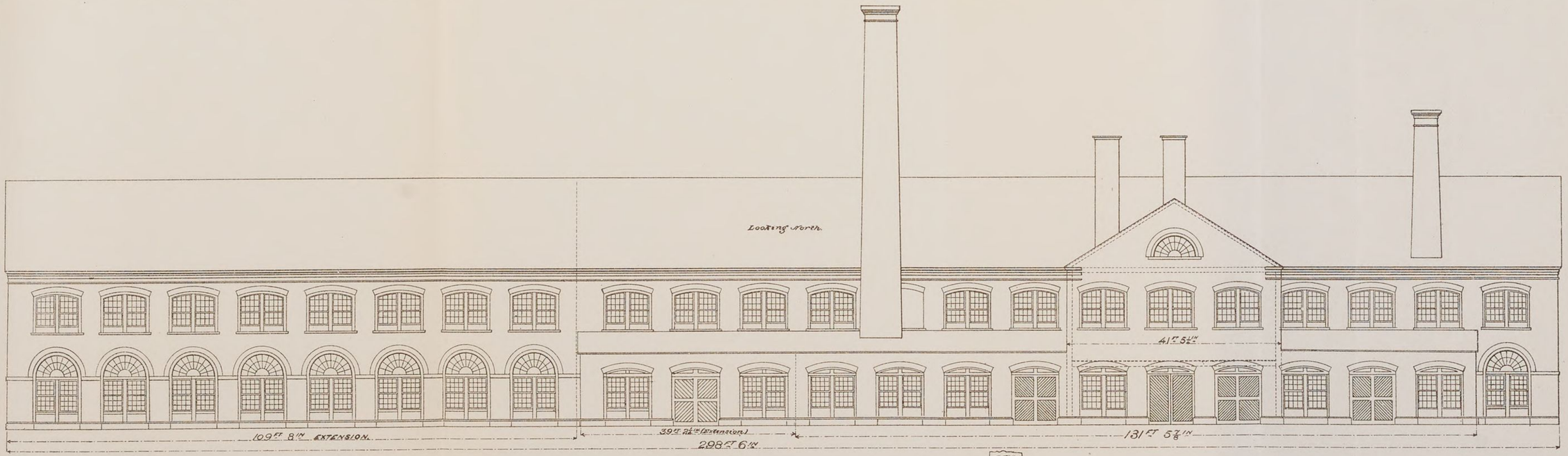
In this department was constructed a shop comparator for the transfer of dimensions from line standards to end measures. A special report has been submitted on this apparatus. The design for a standard comparator is now under consideration.

The wide variety of material submitted for test and the necessity of lengthy preparation in some cases emphasizes the need of another testing machine, one of smaller capacity, to relieve the larger one, economizing time by avoiding frequent changes made necessary when all classes of tests are made on the same machine.

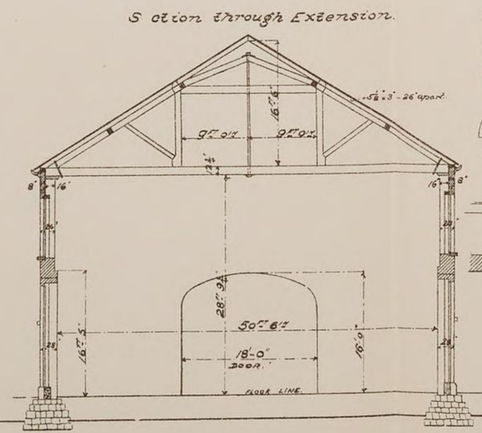
Very respectfully, your obedient servant,

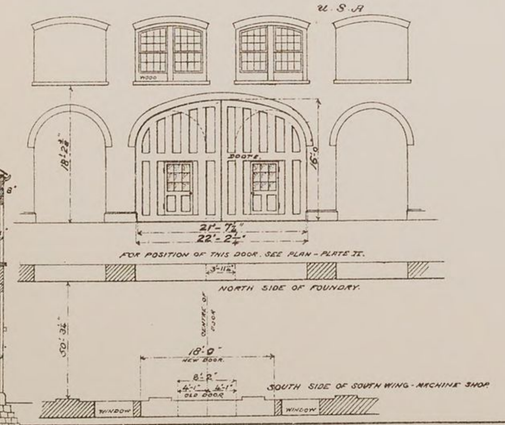
J. W. REILLY,
Major, Ord. Dept., U. S. Army, Commanding.

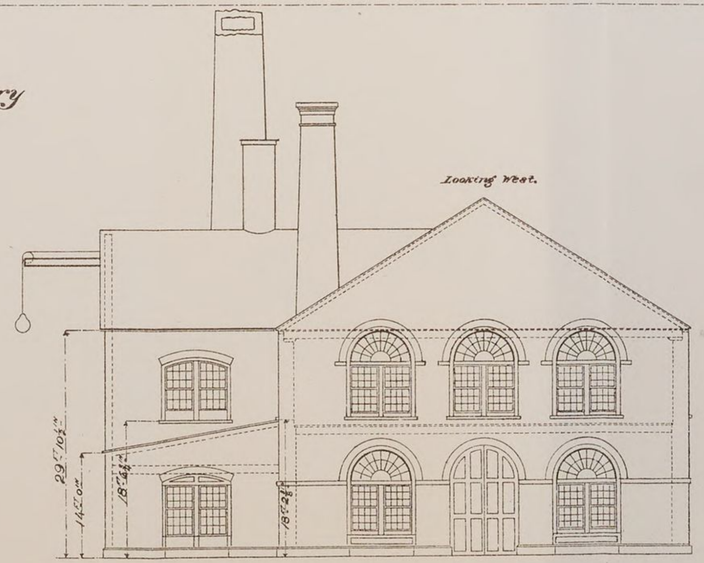
(5092–'93.)



Extended New Foundry
at.
— Watertown Arsenal. —
U. S. A.







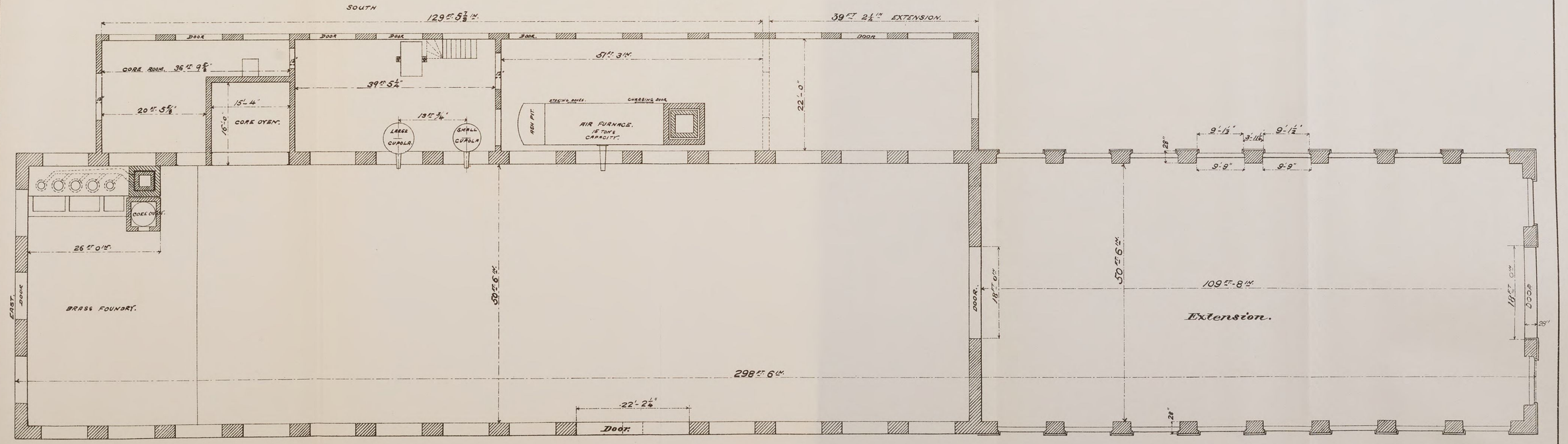
APPROVED: D W Flagler
BRIGADIER GENERAL
CHIEF OF ORDNANCE U.S.A.

Extended New Foundry.

at

Watertown Arsenal

U. S. A.



APPROVED: D W Flagler

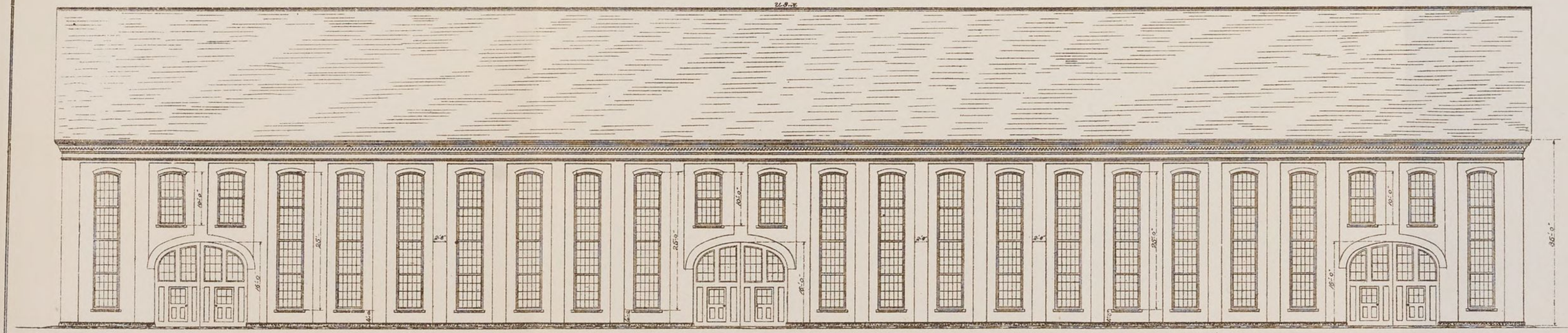
BRIGADIER GENERAL
CHIEF OF ORDNANCE U.S.A.

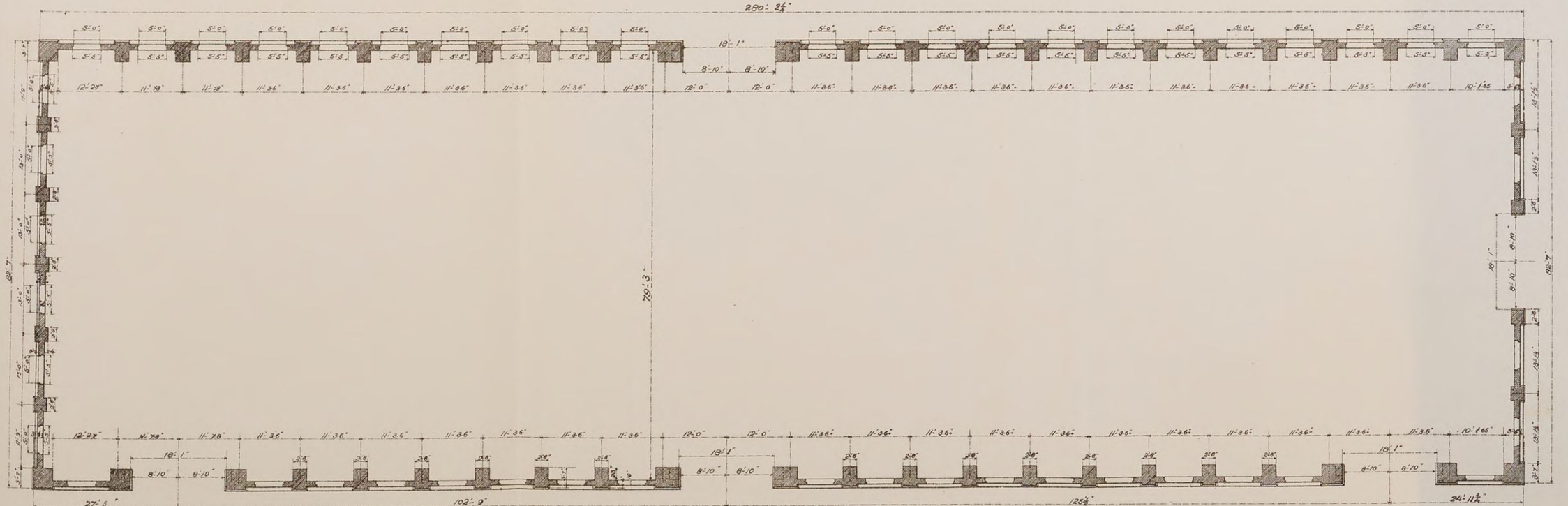
New Setting-Up Shop.

at

Watertown Arsenal.

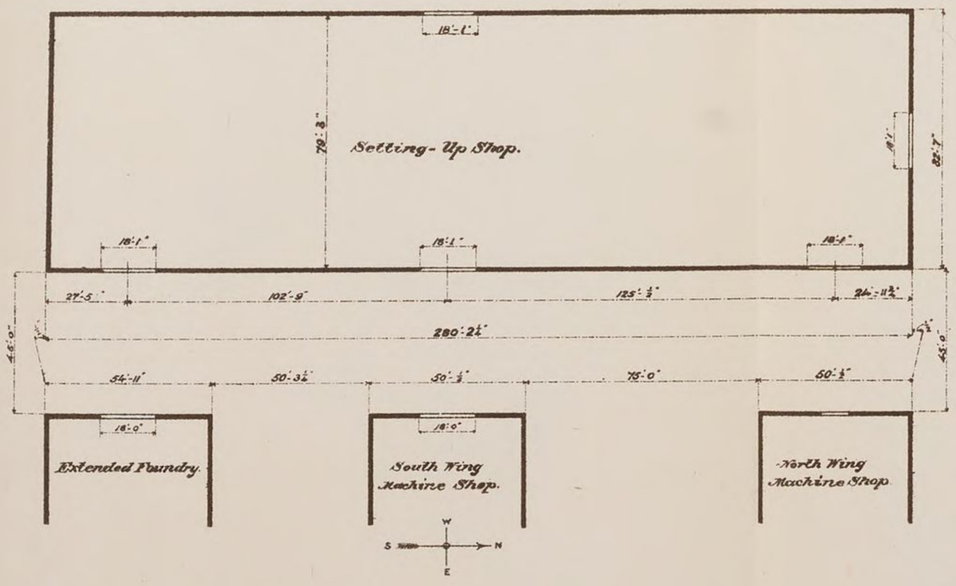
U.S.A.



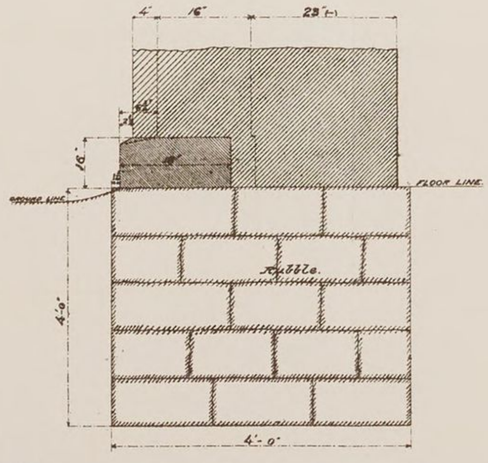


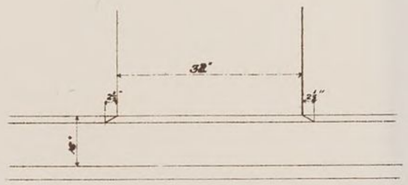
APPROVED:
Nov. 11, 1892.
BRIGADIER GENERAL
CHIEF OF ORDNANCE U.S.A.

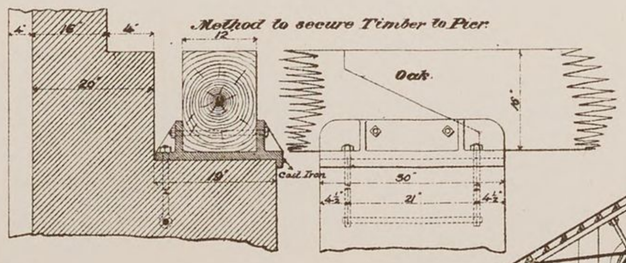
New Setting-Up Shop.
at
Watertown Arsenal.
M.S.W.



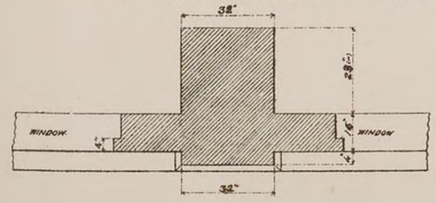
Detail of Foundation.



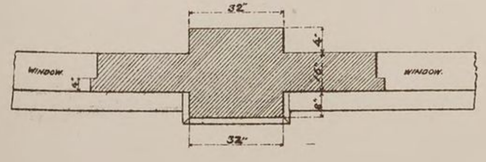


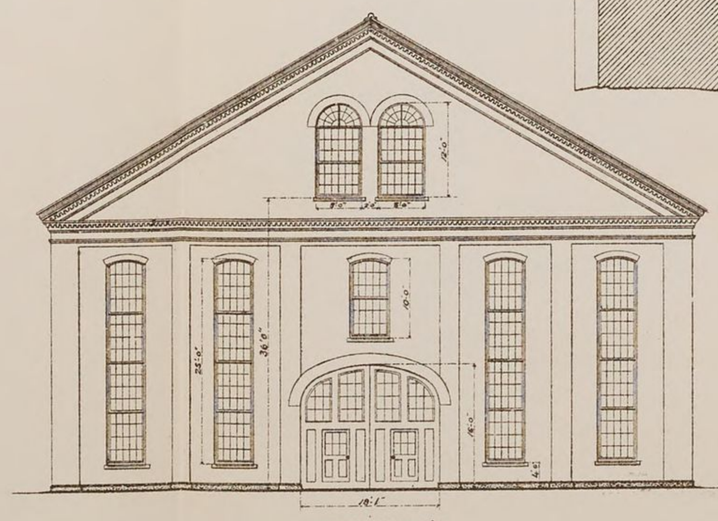


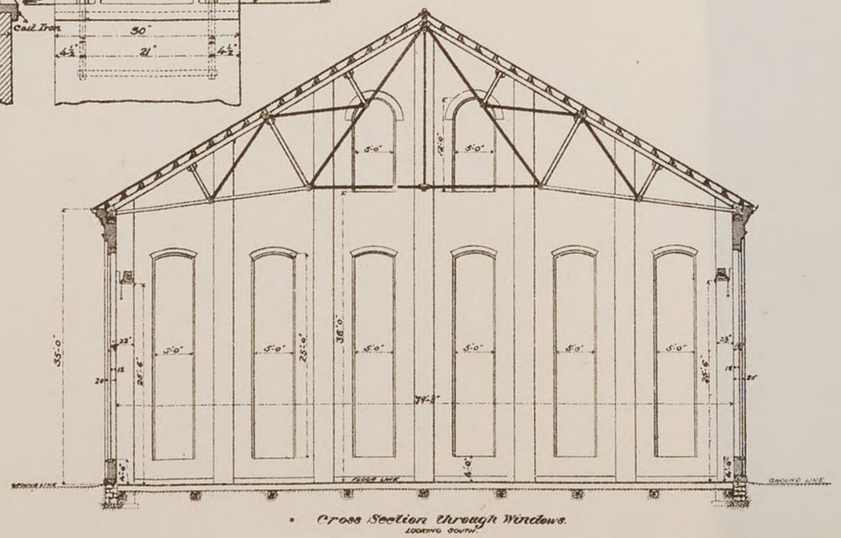
Detail of Side Walls and Piers.



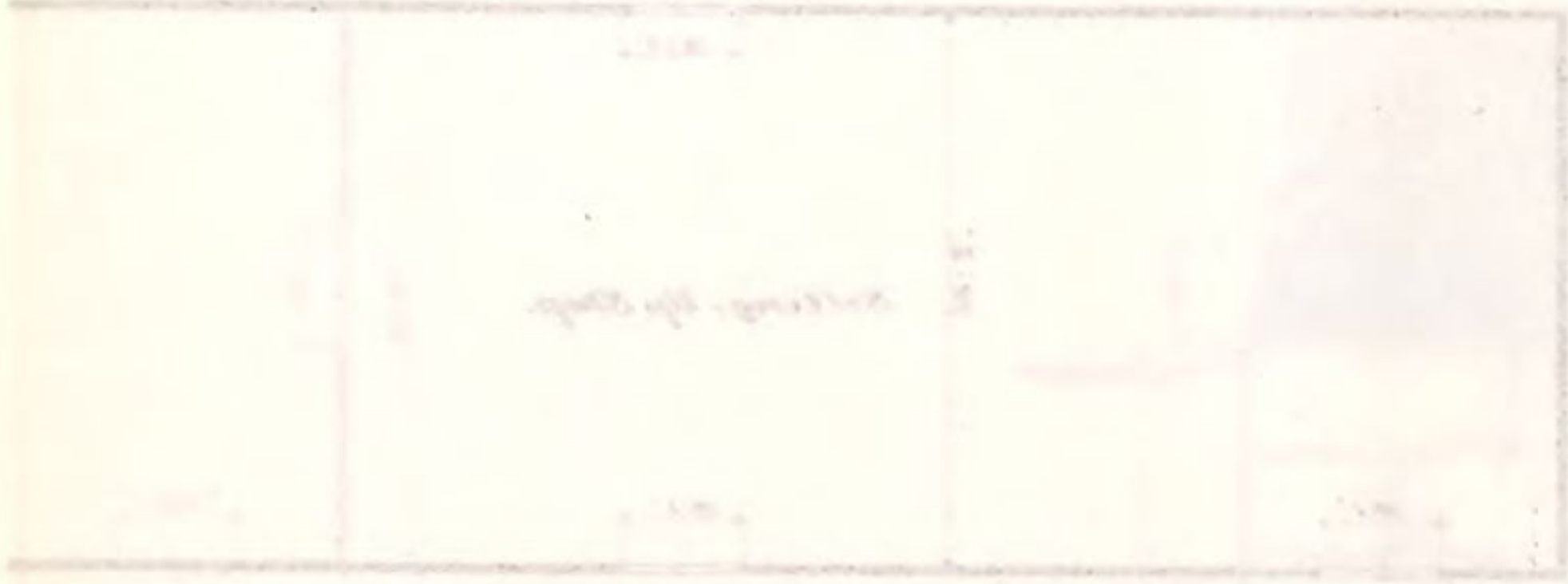
Detail of End Walls and Piers.





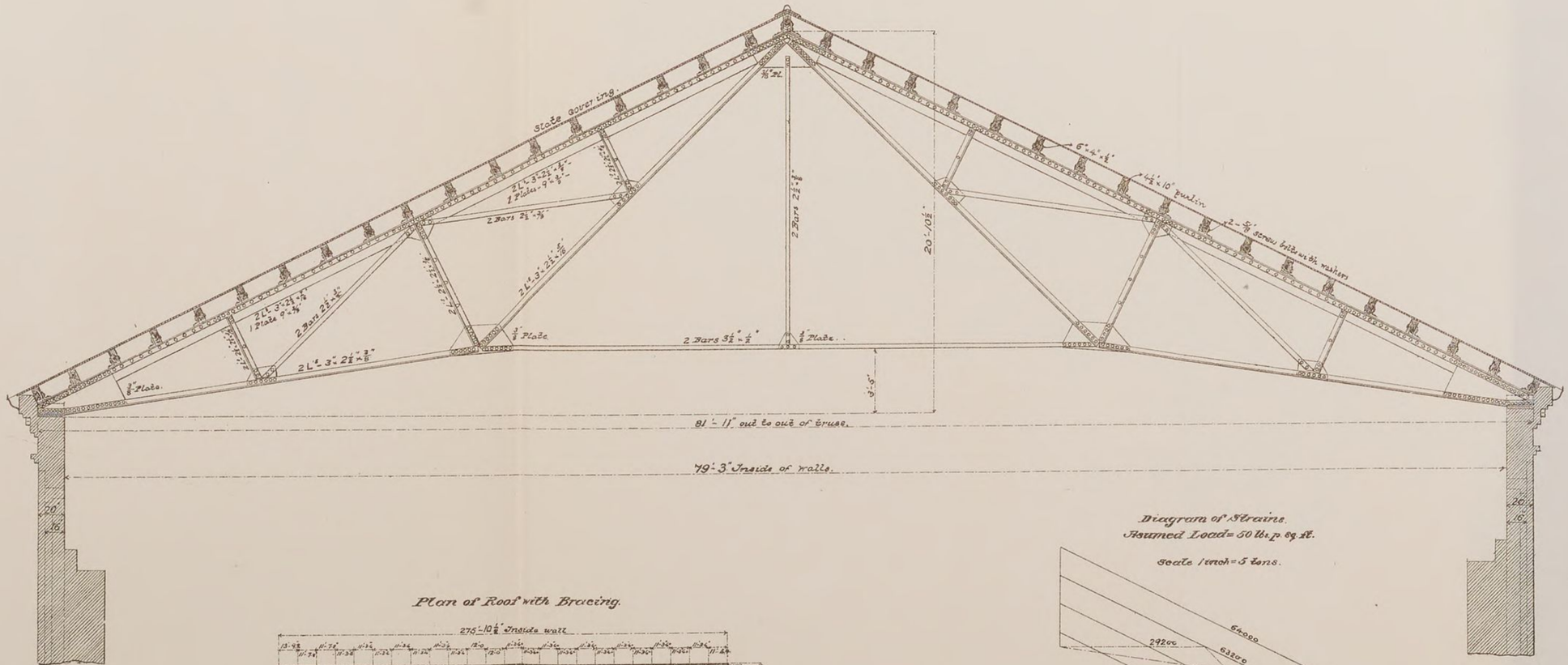


APPROVED:
Nov. 11, 1892.
D. W. Flagler
BRIGADIER GENERAL
CHIEF OF ORDNANCE, U. S. A.



New Setting-Up Shop.
at
Watertown Arsenal.
U.S.A.

Roof Truss.



Plan of Roof with Bracing.

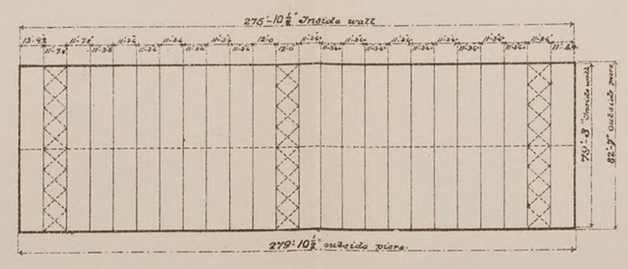
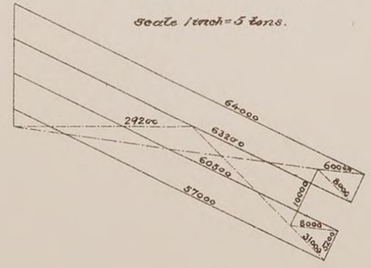


Diagram of Strains.
Assumed Load = 50 lbs. p. sq. ft.

Scale 1 inch = 5 tons.



Approved:
D. W. Flagler
Brigadier General
Chief of Ordnance U.S.A.

APPENDIX 28.

DESCRIPTION OF BARBETTE CARRIAGE FOR 8-INCH B. L. STEEL RIFLE.

(14 plates.)

The carriage consists essentially of the following parts, viz: A bed plate (or lower roller path) of cast iron designed to be held to the platform by sixteen 2-inch bolts; a ring of 20 conical rollers of forged steel resting upon the bed plate; a combined racer (or upper roller path) and chassis of cast iron cast in one piece with transoms, resting upon the live roller ring and fitting over a central pivot or pintle formed in the bed plate; a top carriage of cast steel containing the trunnion beds and hydraulic cylinders cast in one piece and resting upon 16 recoil rollers of forged steel placed in pockets formed in the chassis.

The trunnions of the gun are retained in their beds by cap squares fitted to under-cut recesses of the top carriage and bolted down. Clips on the outside of the top carriage prevent its rising from the chassis. The piston rods of the hydraulic cylinders are attached at their forward ends to projections cast on the front part of the chassis. These projections serve also as part supports to a gun shield which may be bolted to the chassis.

Uniformity of resistance in the hydraulic cylinders during recoil is obtained by throttling bars of uniform width and varying depth bolted along elements of the cylinders, two in each, the pistons being slotted to slide over the bars. The profile of these throttling bars is so calculated as to insure nearly a constant resistance in the hydraulic brake. An equalizing pipe connects the forward ends of the hydraulic cylinders, and filling and emptying holes are provided at rear and front of cylinders. The computed recoil is 40 inches, using neutral oil in the cylinders, and the actual recoil with full charges differs little from this. The piece returns to battery after recoil by the action of gravity, the slope of the chassis being 4 degrees. The rear cylinder covers are provided with cup-shaped recesses, and the prolongations of the piston rods shaped to fit these with a slight clearance. On entering recesses they act as counter-recoil buffers, diminishing the shock of running into battery.

ELEVATING MECHANISM.

This consists of a shaft supported in bearings attached to the right side of chassis. The shaft is square throughout, except at the bearings. It is actuated by two hand wheels and shaft at the front of carriage through the medium of mitered gearing. Another miter gear works in a bearing cast on the upper carriage. This miter, by a shoulder at one end and nut at the other, bears against the lug which carries it freely along the shaft during recoil, but it is forced to turn when the shaft is

rotated. It gears with a second miter attached to an upright shaft working in bearings cast on the top carriage. This shaft carries a worm actuating through the medium of a worm wheel a horizontal shaft and pinion, the elevating arc attached to gun. The worm wheel of the elevating gear has a friction clutch to permit motion to the gear during recoil without straining the elevating mechanism. The gun can be elevated from either side of the carriage or from the loading platform by a hand wheel. The carriage permits of an elevation of gun from $-7°$ to $+18°$.

TRAVERSING GEAR.

For traversing a chain passes around bed plate and over a sprocket wheel. Upon the same shaft with the sprocket, and attached to it by a clutch coupling, is a worm wheel actuated by a worm worked by a crank shaft with two handles. Before engaging the sprocket wheel the chain passes over two guide wheels, which are journaled in two swiveling supports working through brackets bolted to chassis. To the ends of the chain are attached two heavy bolts with threaded ends. These pass through two lugs cast on bed plate and are provided with hexagonal nuts, by screwing up which the tension of the chain may be regulated.

The piece can be moved in any direction through an angle of about $320°$. The chassis rests upon the bed plate by means of a ring of conical rollers. These rollers are held between two wrought-iron distance rings notched to receive the journals of rollers. Four guide hooks of forged steel engaging under flange of lower roller path prevent the rising of chassis. The rollers are protected from dust and dirt by a sheet-steel dust guard bolted to the upper roller path and overlapping the lower.

SHOT HOIST.

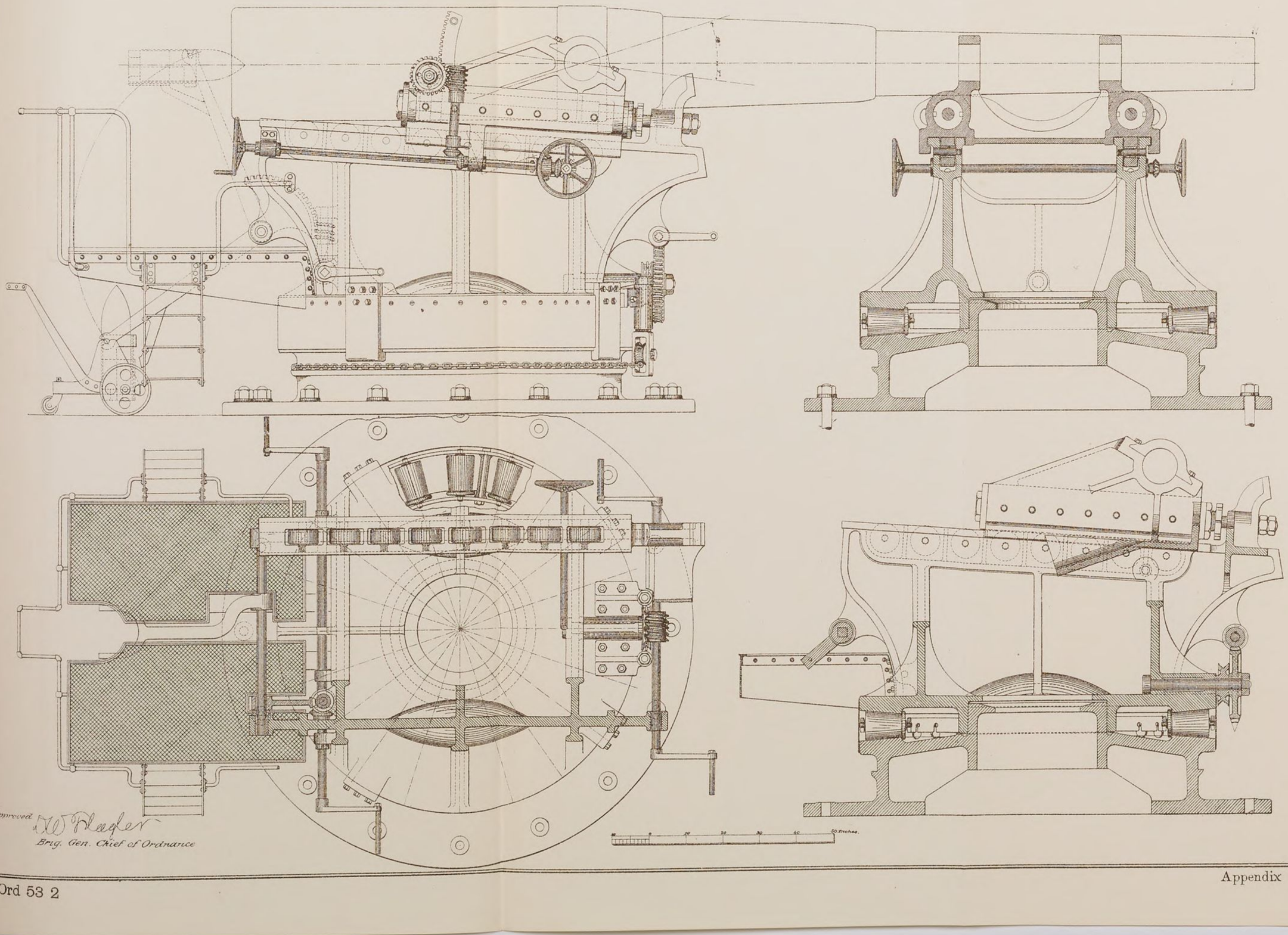
The hoisting of shot is effected by a forked arm rotated to a position in rear of breech by means of a crank shaft actuating a worm gearing. The projectile is carried in a tray provided with trunnions fitting into notches in the cheeks of a shot truck. This truck is brought up in rear of gun carriage and placed in such a position that cheeks of truck overlap the two prongs of shot hoist, and notches cut in the prong arms engage trunnions of shot tray. The tray is then revolved to a position at the breech in line with the axis of the bore.

For convenience in loading the shot on the truck in the magazine, the tray is held in a horizontal position on the truck by a securing pin passed through the arms of truck underneath the tray. This is removed as soon as shot is loaded on the truck.

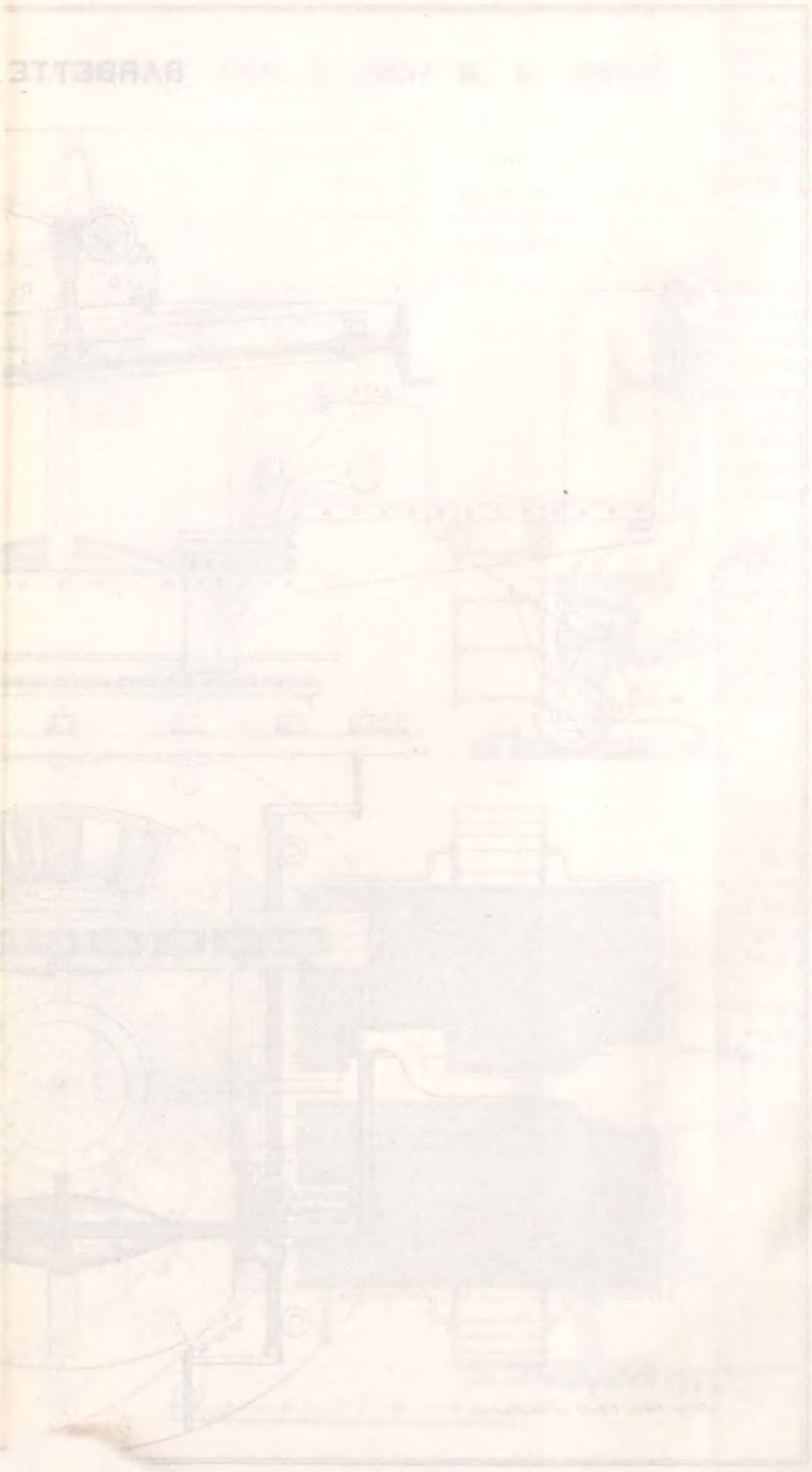
A platform attached to chassis affords standing room for operating breech mechanism, etc. The total weight of carriage is 55,418 pounds. The combined weight of the moving parts is 35,568 pounds.

(446–'93.)

BARBETTE CARRIAGE FOR 8 INCH B. L. RIFLE.



Approved D W Flagler
Brig. Gen. Chief of Ordnance



Barbette Carriage for 8 inch B.L. Rifle.

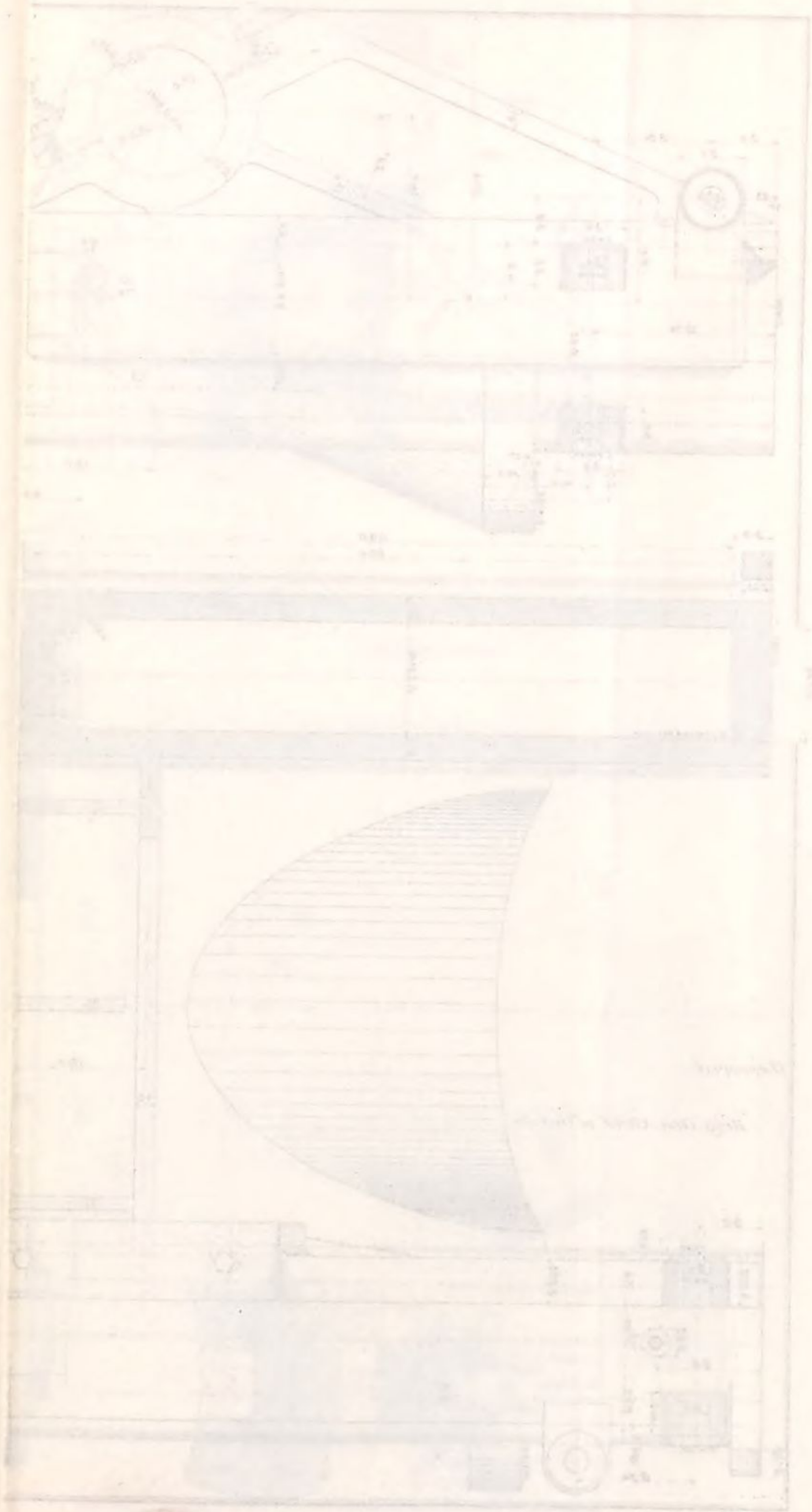
Top Carriage.

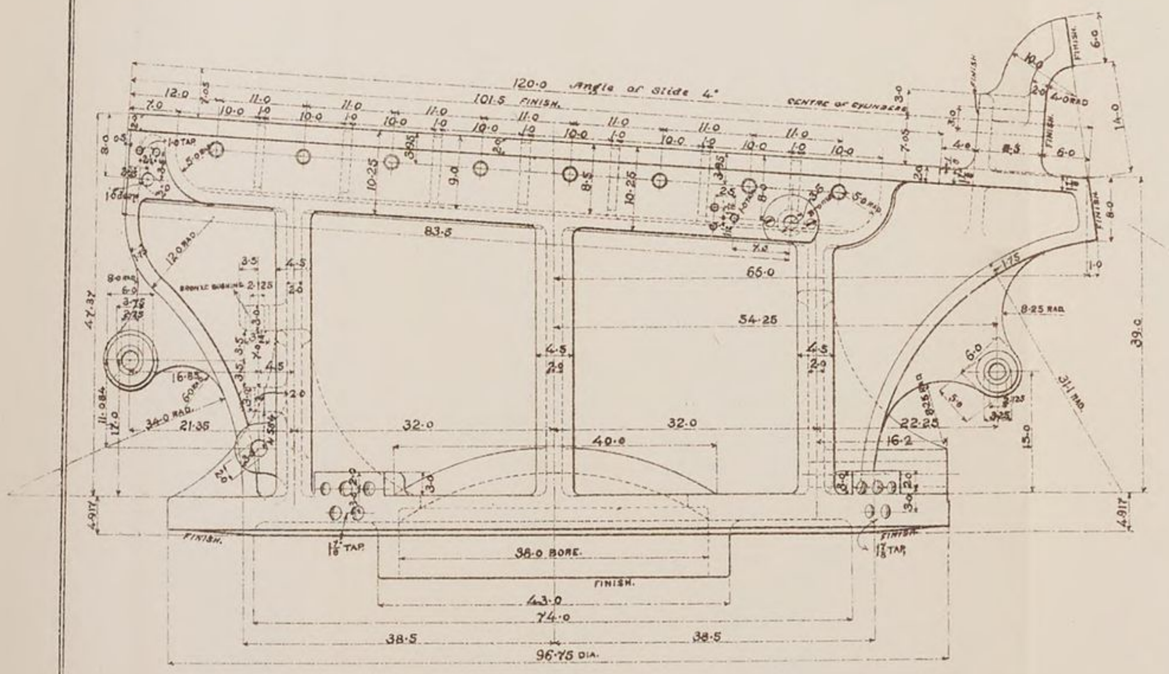
— *Steel Casting.* —

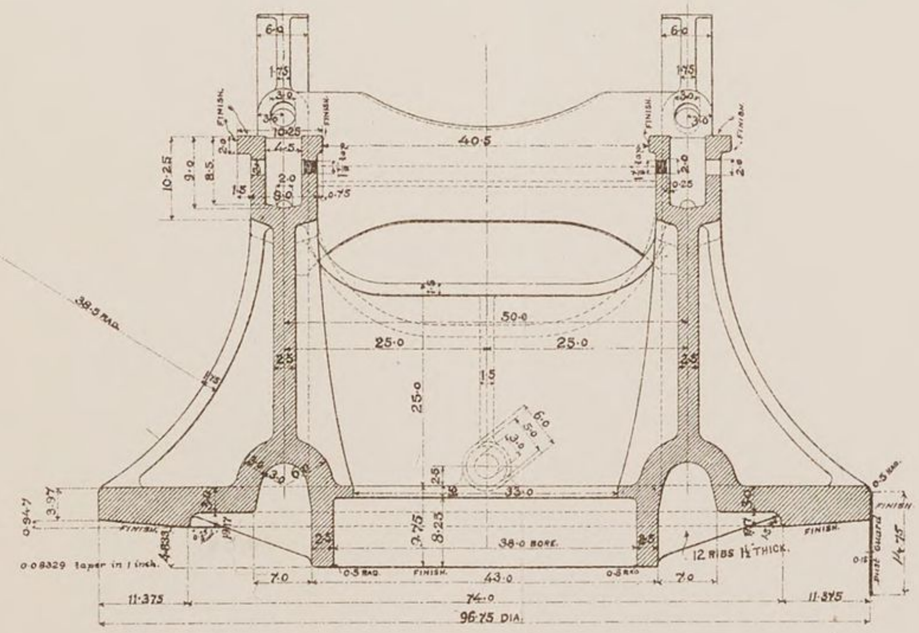
Approved:

Brig. Gen. Chief of Ordnance.

Equalizing Connection.



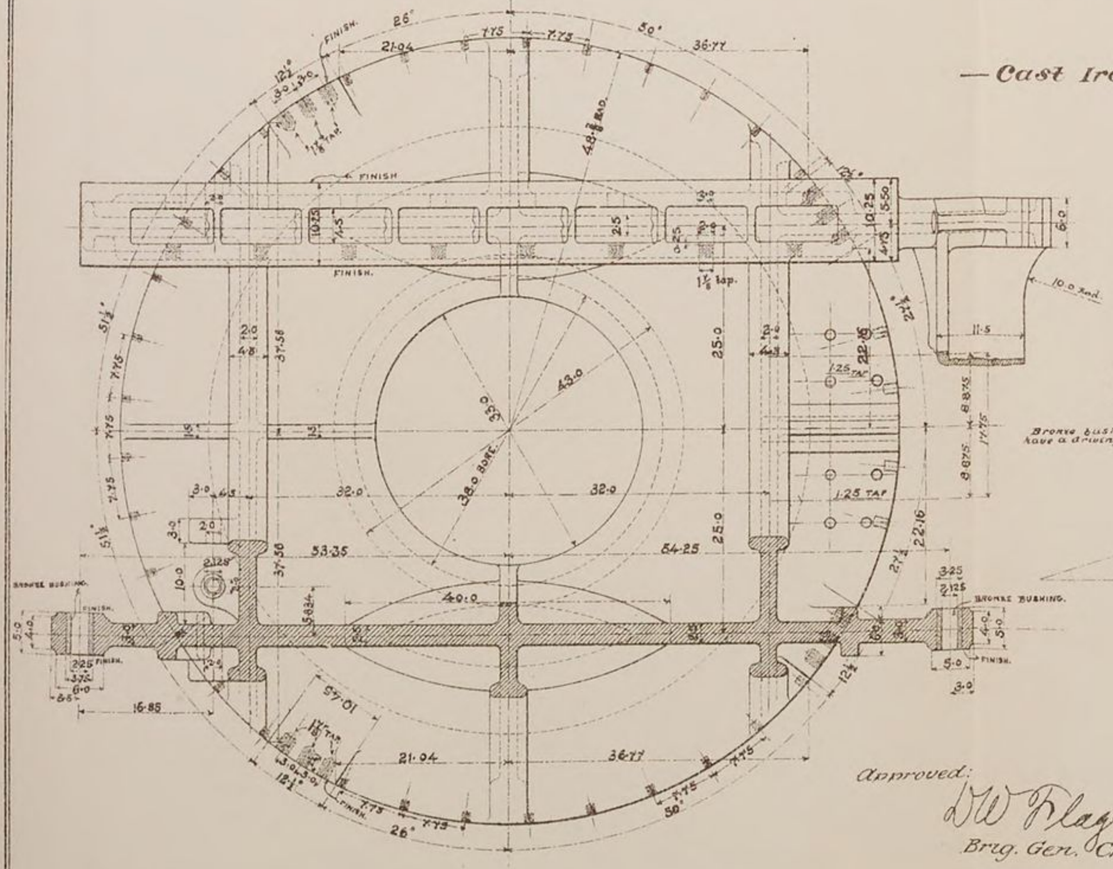


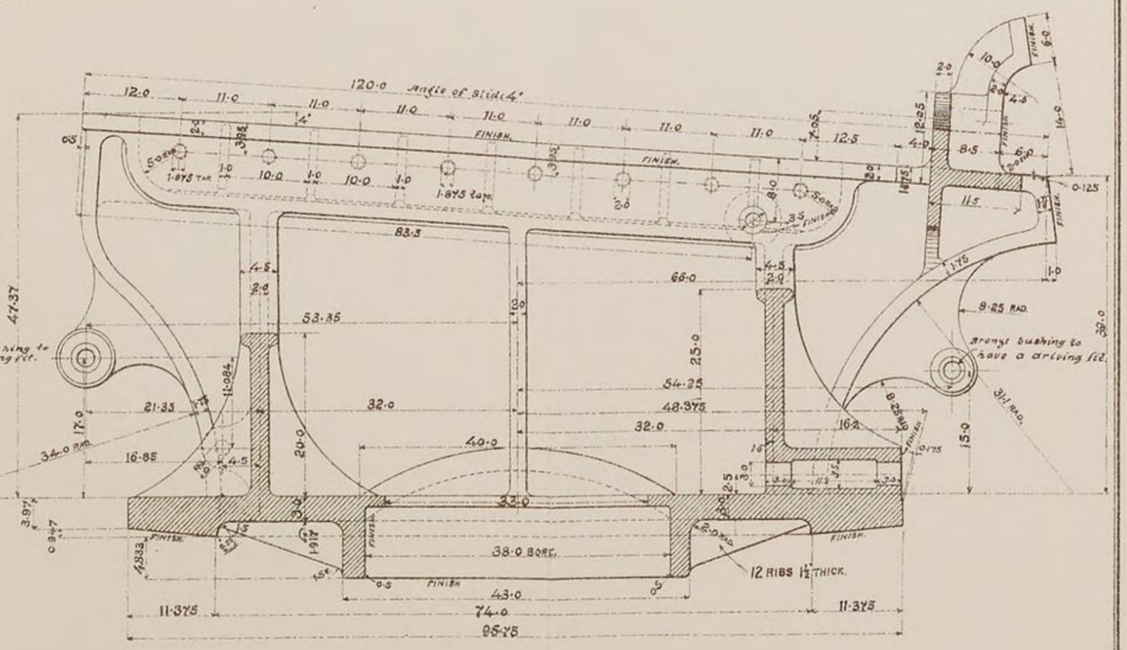


Barbette Carriage for 8 inch B.L. Rifle.

— Chassis. —

— Cast Iron. —



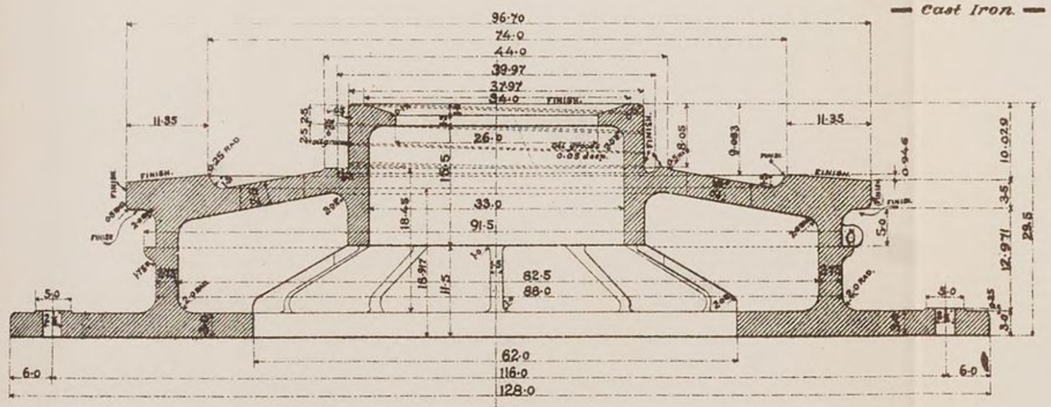


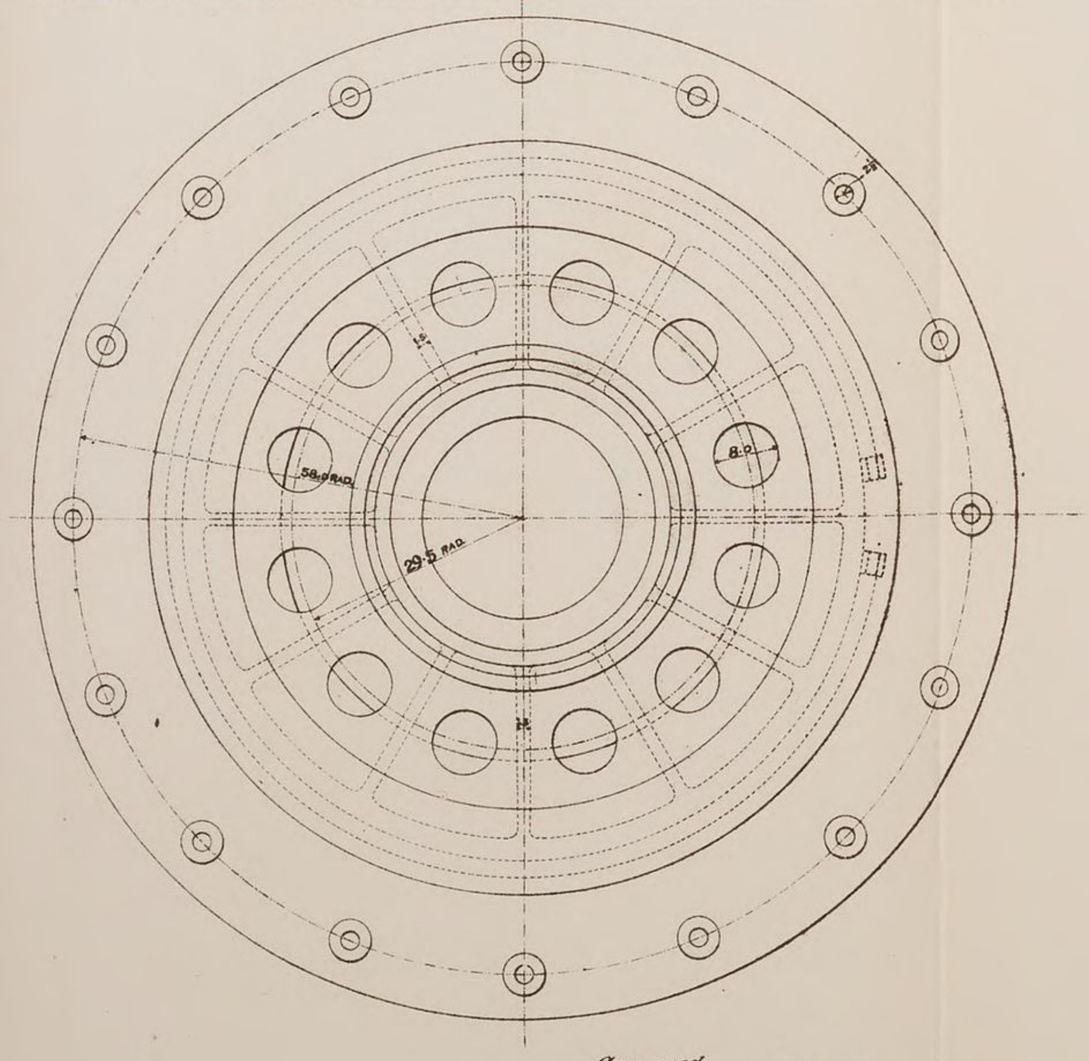
Approved:
D W Flagler
Brig. Gen. Chief of Ordnance

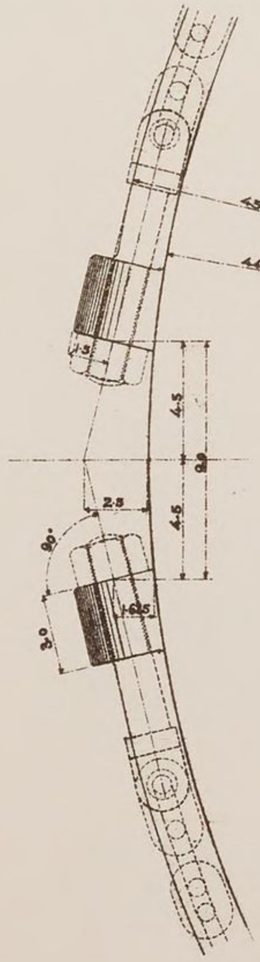
Barbette Carriage for 8 inch B.L. Rifle.

Lower Roller Path.

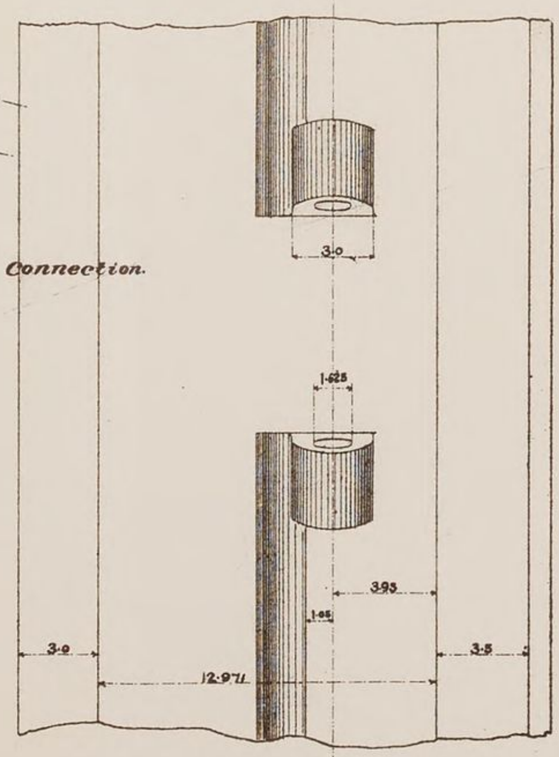
— Cast Iron. —





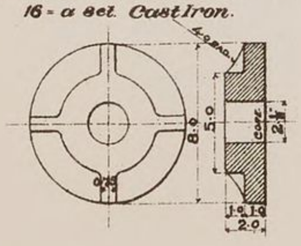


Chain Connection.



Washer for Foundation Bolt

16 - a set. Cast Iron.



Approved

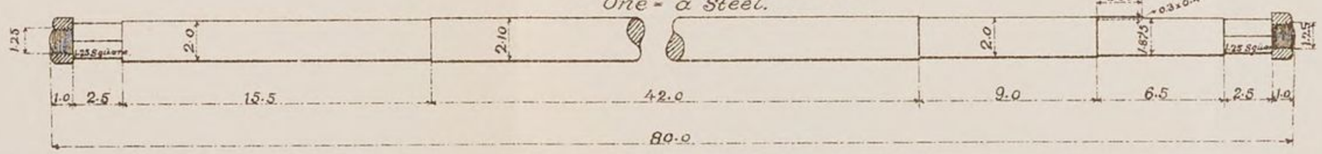
D W Flagler.

Brig. Gen. Chief of Ordnance

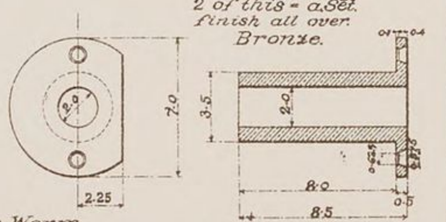
Barbette Carriage for 8 inch B.L. Rifle.

— Elevating Apparatus. —

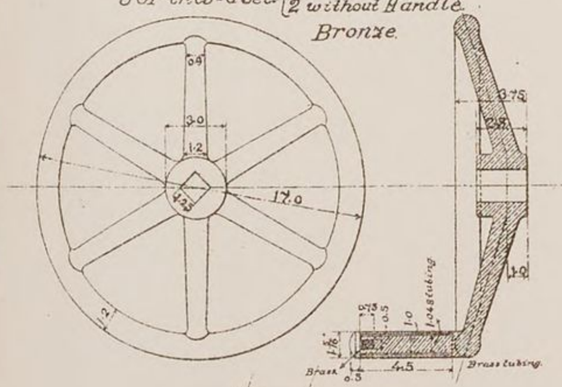
Shaft of Forged Steel.
One = a Steel.



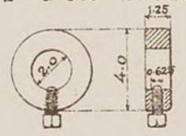
Bushing.
2 of this = a Set.
finish all over.
Bronze.



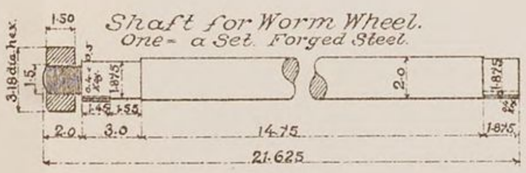
Hand Wheel.
3 of this = a Set. { 1 with Handle. 2 without Handle.
Bronze.



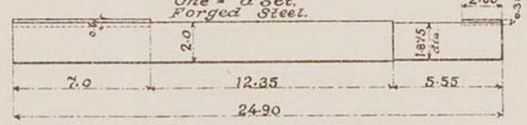
Collar.
2 = a Set. Wrt Iron.



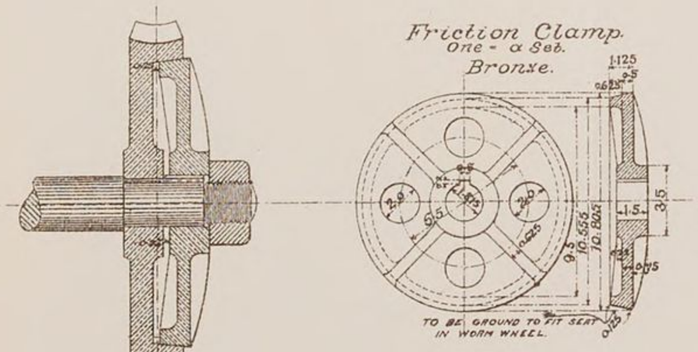
Shaft for Worm Wheel.
One = a Set. Forged Steel.



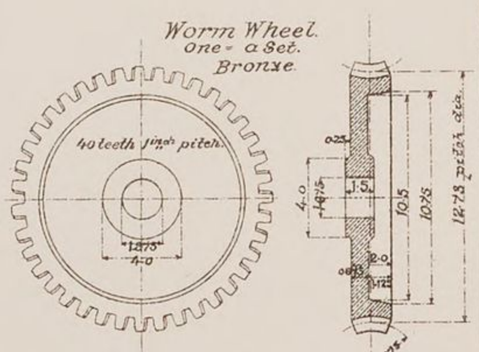
Shaft for Worm.
One = a Set.
Forged Steel.



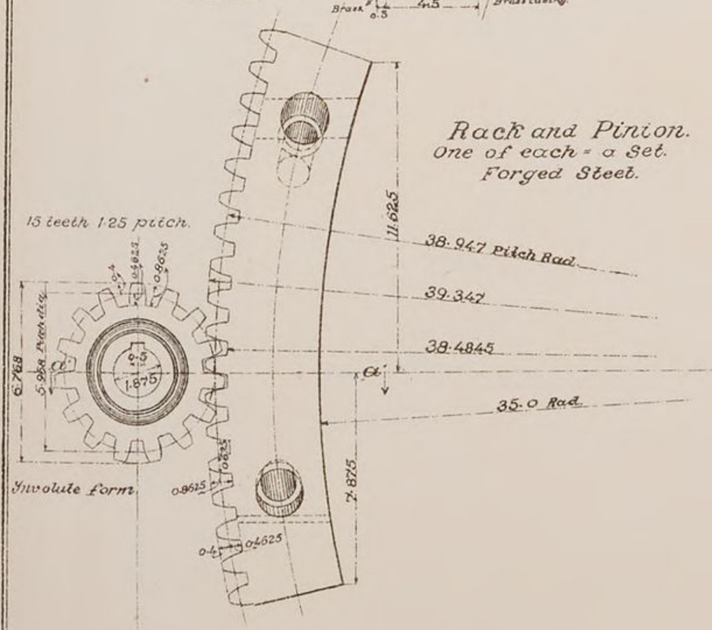
Friction Clamp.
One = a Set.
Bronze.

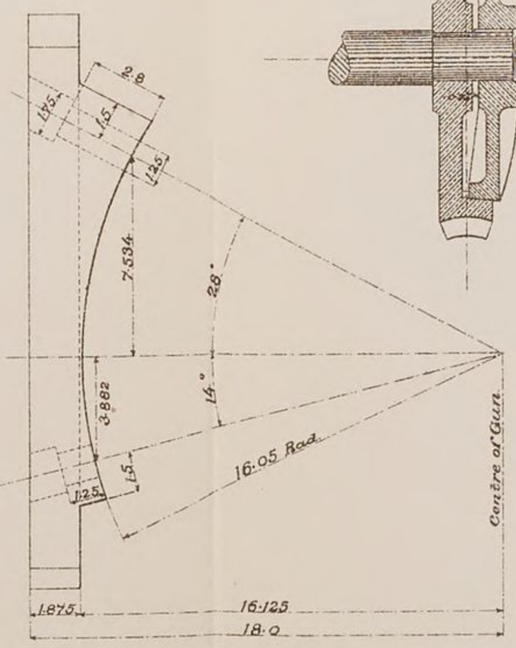


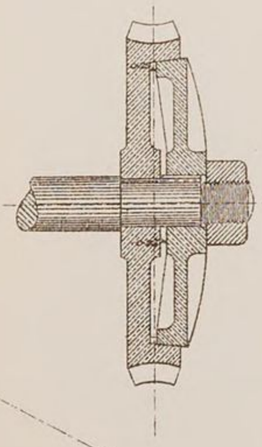
Worm Wheel.
One = a Set.
Bronze.



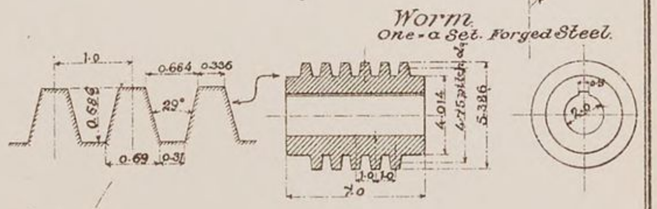
Rack and Pinion.
One of each = a Set.
Forged Steel.

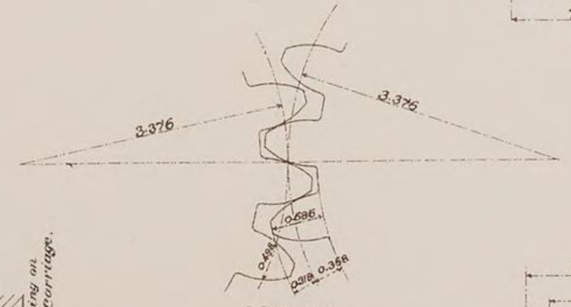




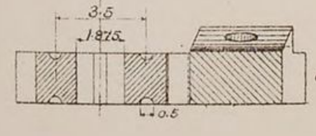


Worm
One = a Set. Forged Steel.

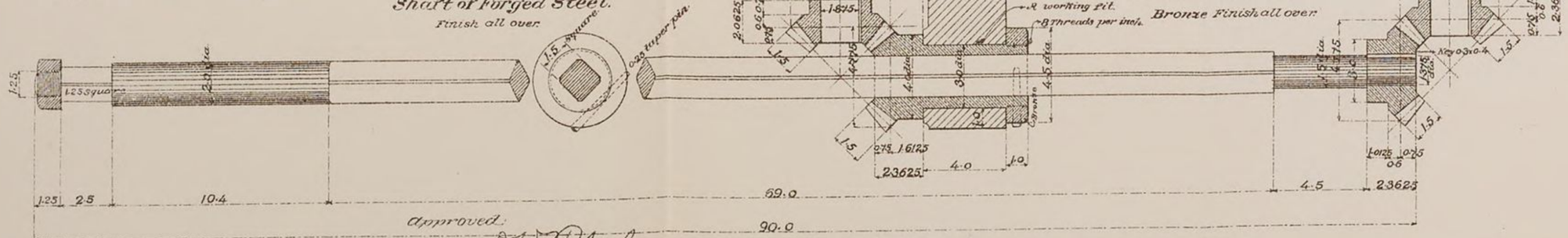




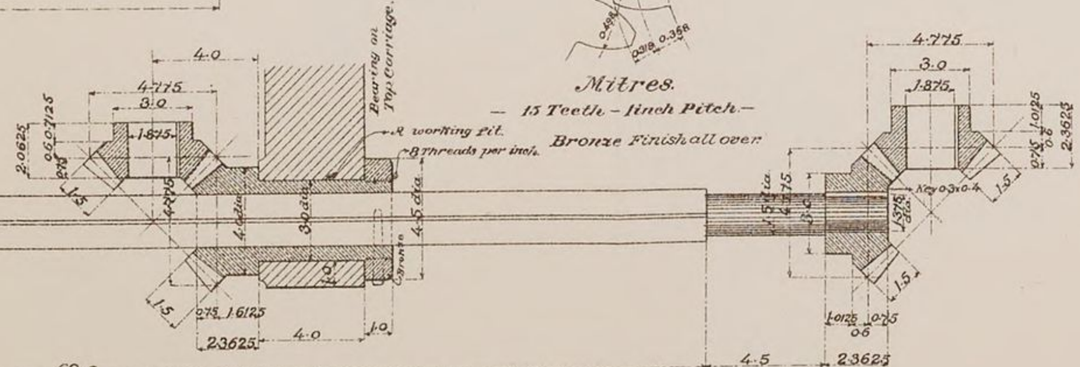
Section "A.A."



Shaft of Forged Steel.
Finish all over.



Mitres.
— 15 Teeth - Inch Pitch. —
Bronze Finish all over.

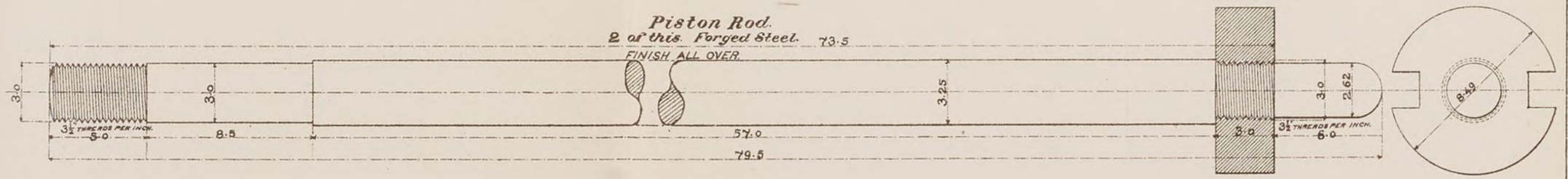


Approved.
D D Blagden
Brig. Gen. Chief of Ordnance

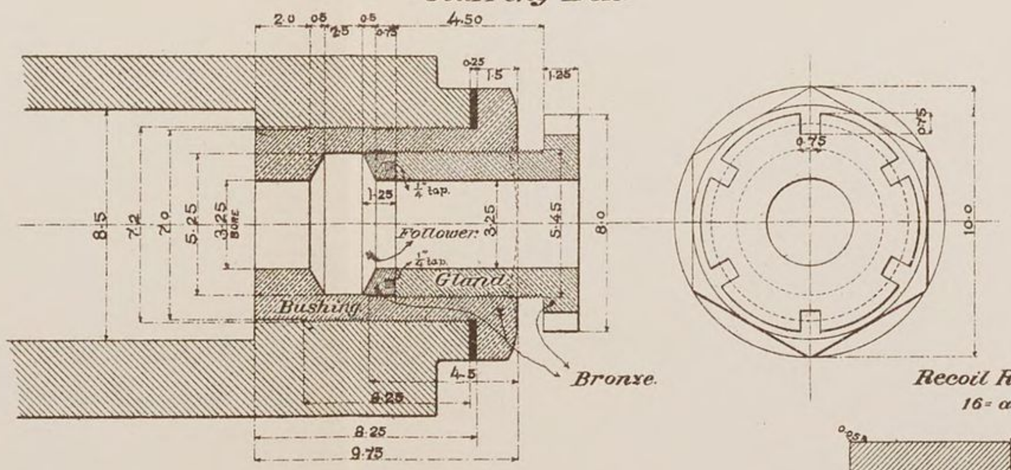
Barbette Carriage for 8 inch B.L. Rifle.

Piston Rod.

2 of this. Forged Steel.

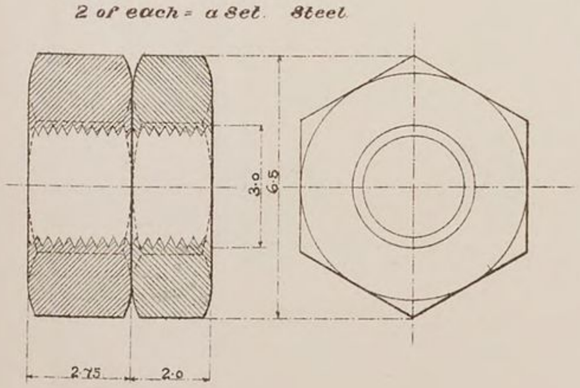


Stuffing Box.



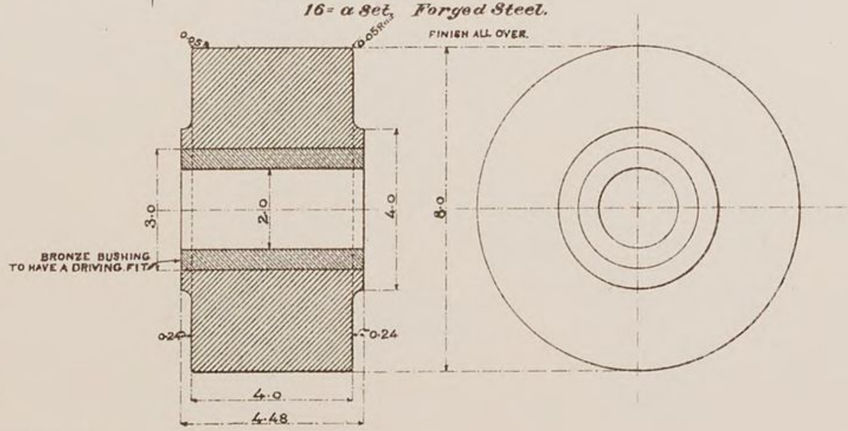
Nuts for Piston Rod.

2 of each = a Set. Steel.



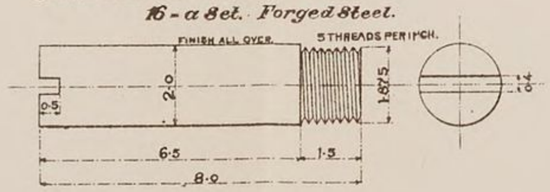
Recoil Rollers.

16 = a Set. Forged Steel.



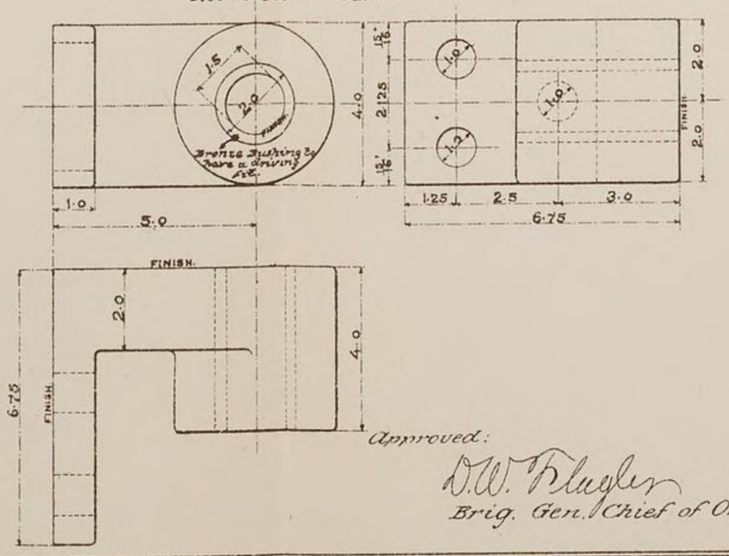
Journal for Recoil Rollers.

16 - a Set. Forged Steel.



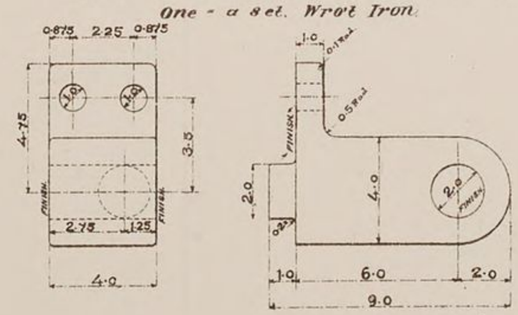
Front Bearing for Elevating Shaft.

One = a Set. Wrot Iron.



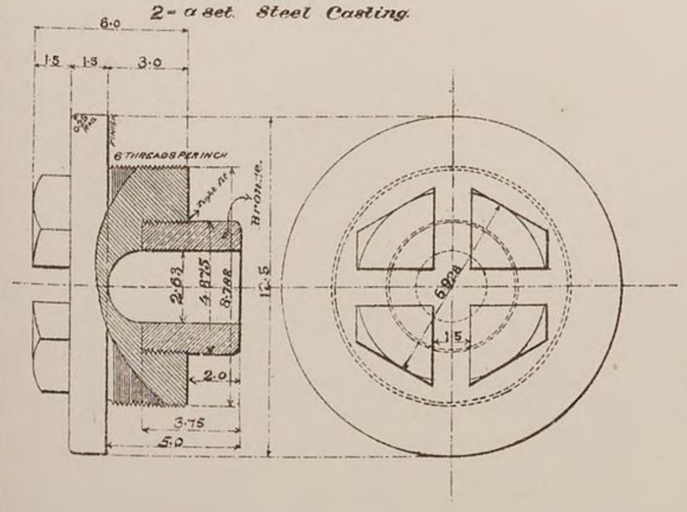
Rear Bearing for Elevating Shaft.

One - a Set. Wrot Iron.



Rear Cylinder Cover.

2 = a set. Steel Casting.



Approved:

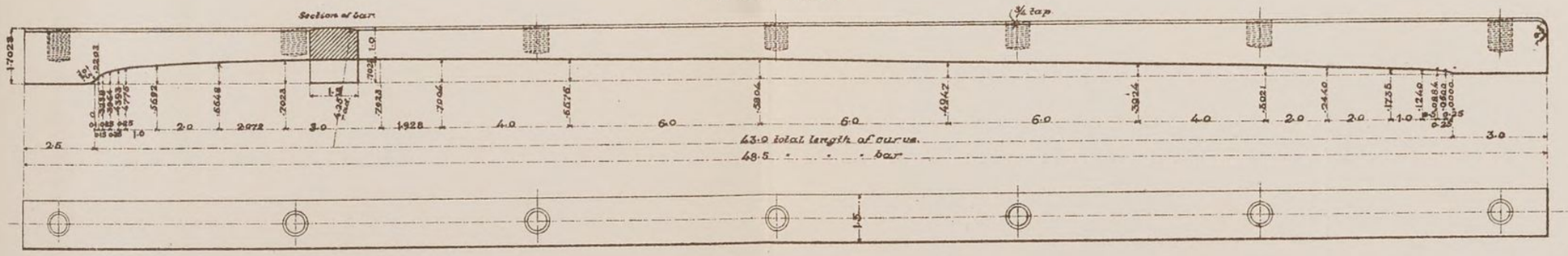
D.W. Flagler

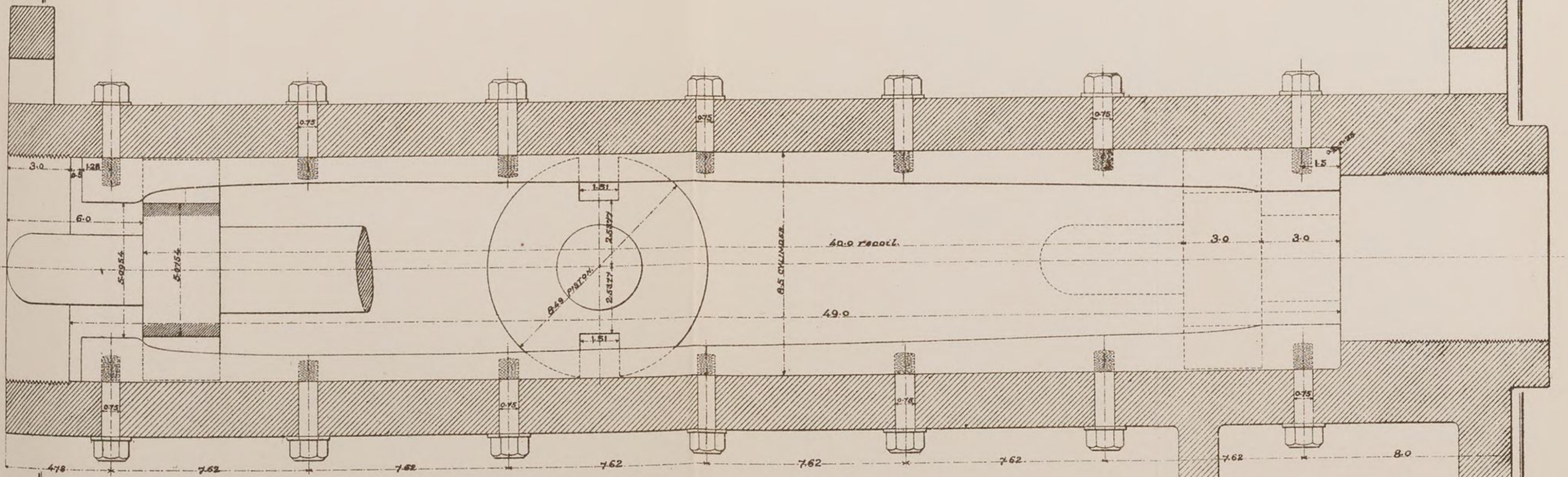
Brig. Gen. Chief of Ordnance

Barbette Carriage for 8 inch B.L. Rifle.

— Recoil Brake. —

Throttling Bar:
4 - a Set. - Steel.



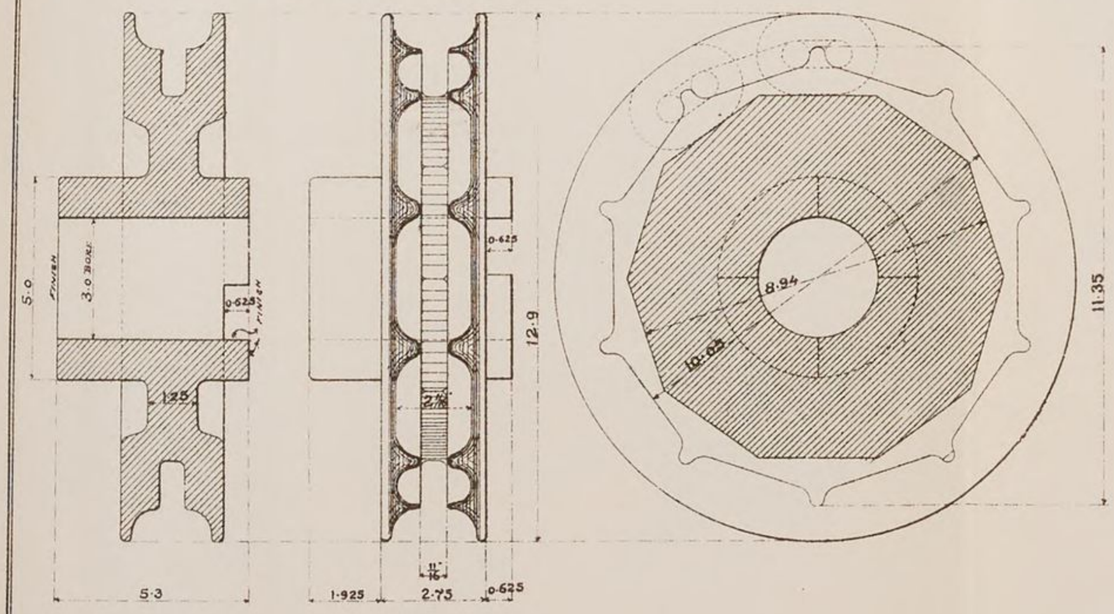


Approved:
D W Flagler
Brig. Gen. Chief of Ordnance.

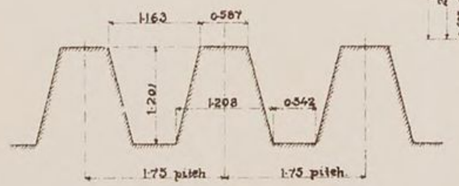
Barbette Carriage for 8 inch B.L. Rifle.

—Traversing Apparatus.—

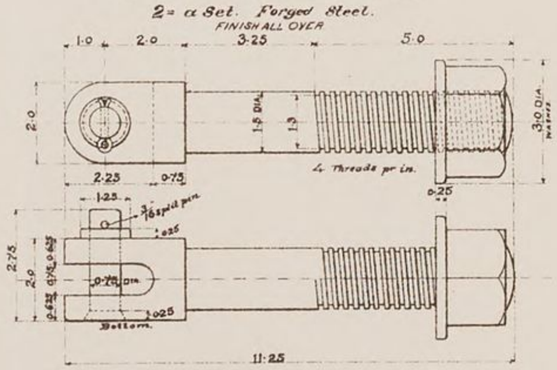
Sprocket Wheel.
One - a Set. Cast Iron.



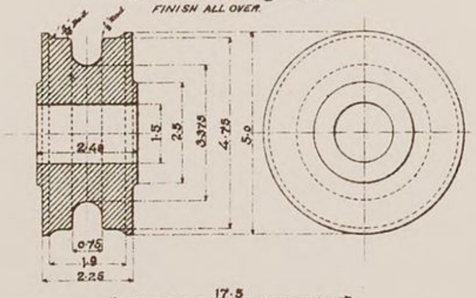
Development of Thread of Worm.



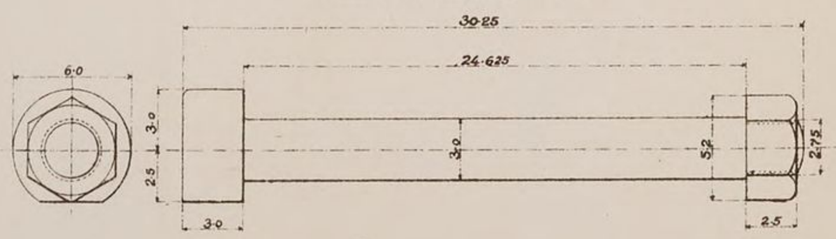
Bolt Connecting Chain to Lugs.
2 = a Set. Forged Steel.
FINISH ALL OVER



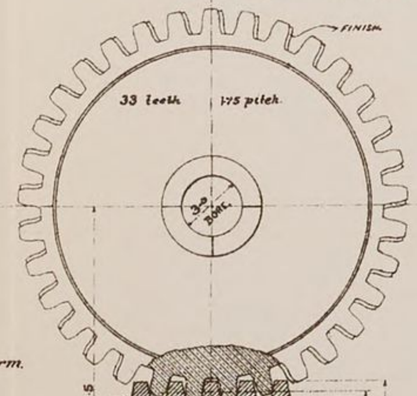
Guide - Wheel.
2 = a Set. Wrought Iron.
FINISH ALL OVER.

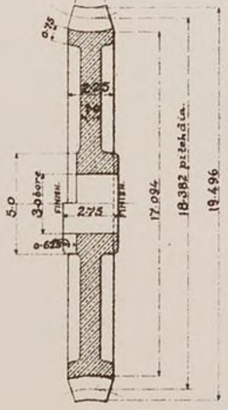


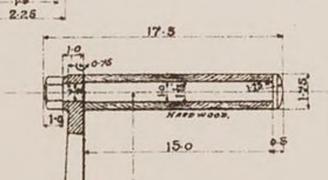
Journal for Worm Wheel
One - a Set. Forged Steel. FINISH.

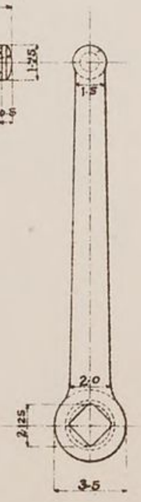


Worm Wheel.
One - a set. Bronze.



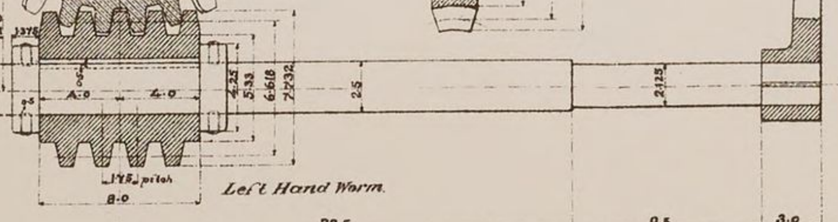


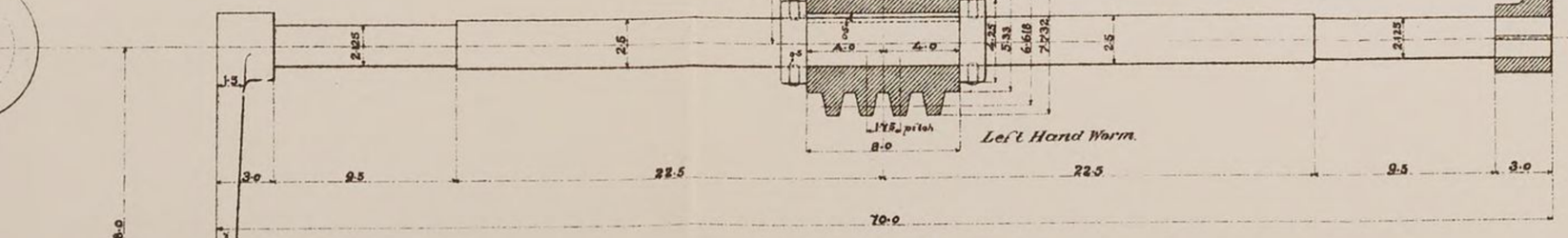




Hob Wheel to fit Worm.

Left Hand Worm.

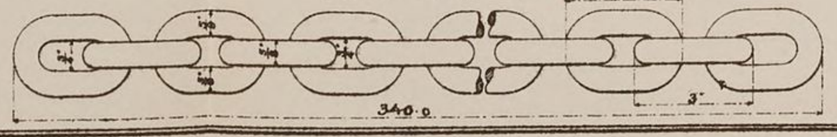




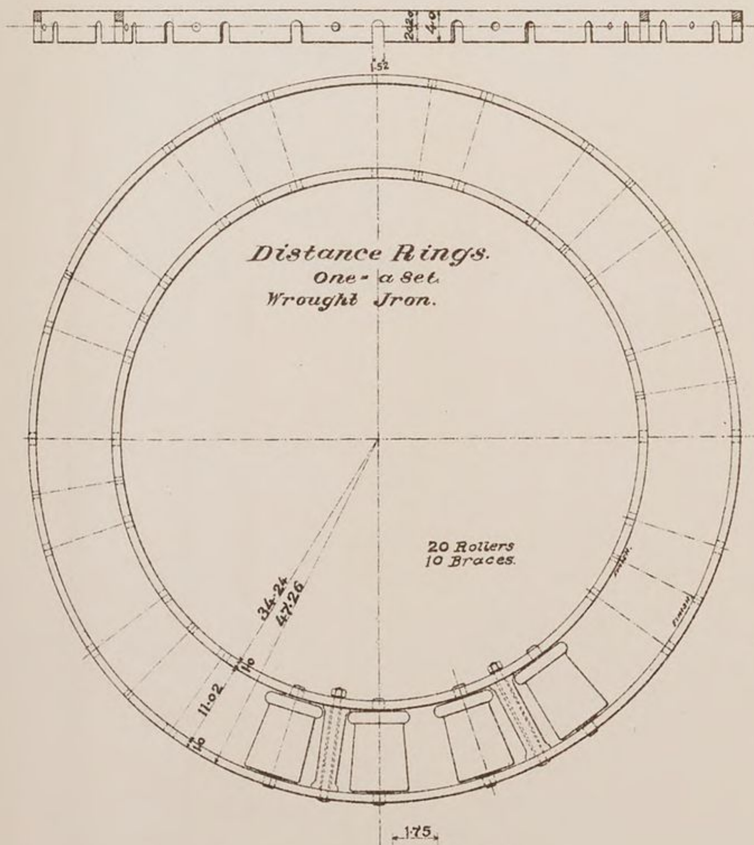
Approved:
D W Flagler.
Brig. Gen. Chief of Ordnance

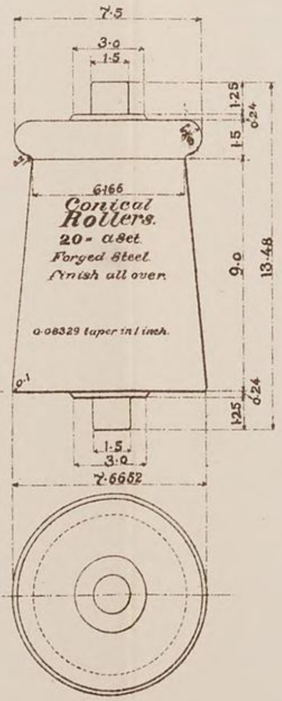
Crank Shaft.
One - a Set. Forged Steel.
FINISH.

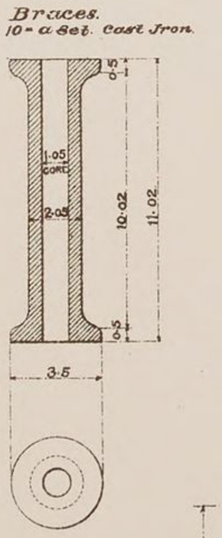
Chain. Wrought Iron.

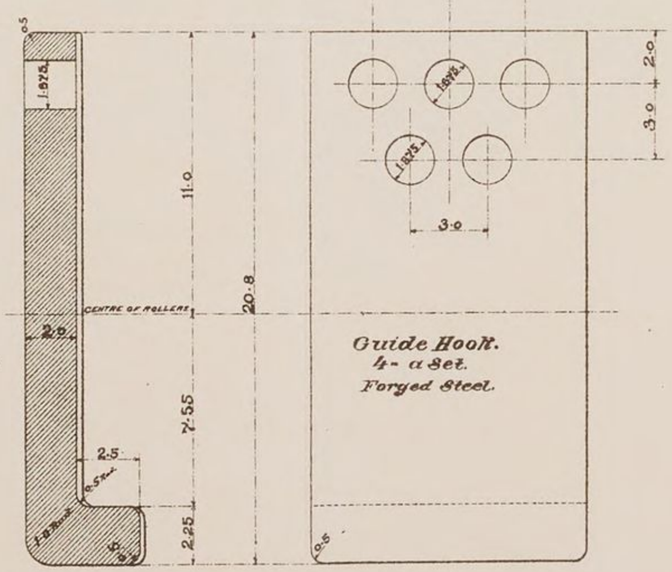


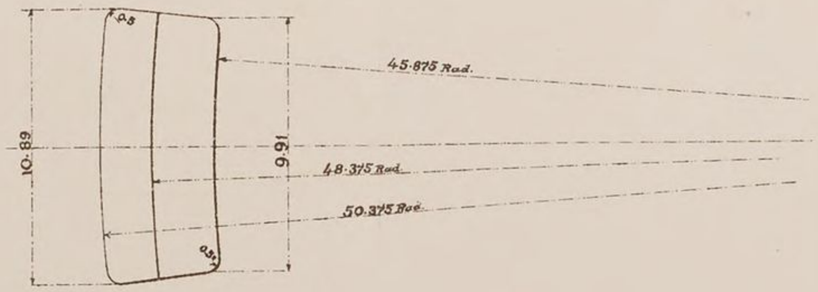
Barbette Carriage for 8 inch B.L. Rifle.

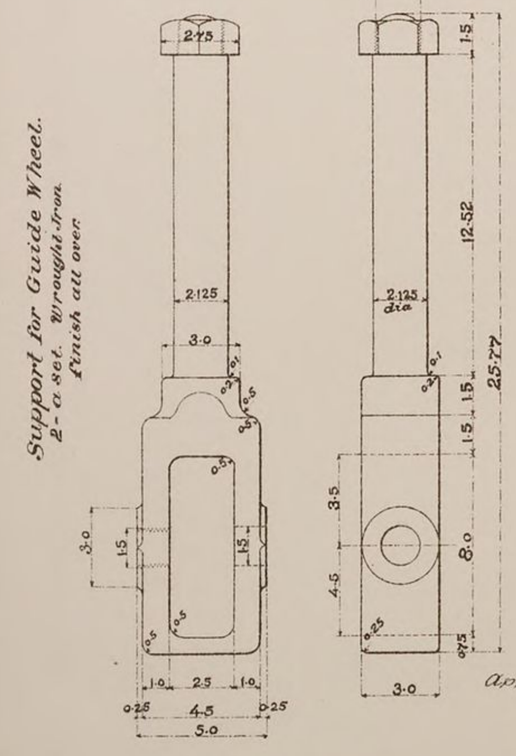


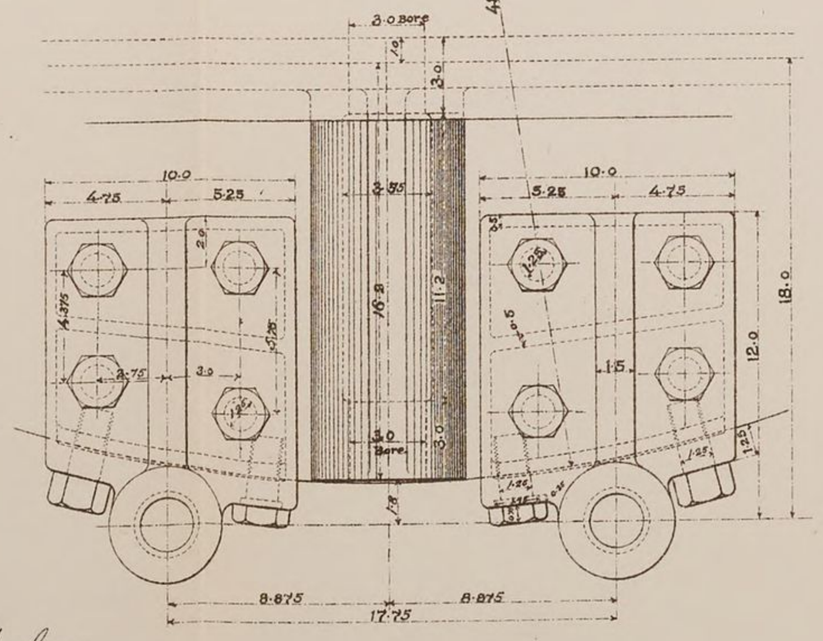


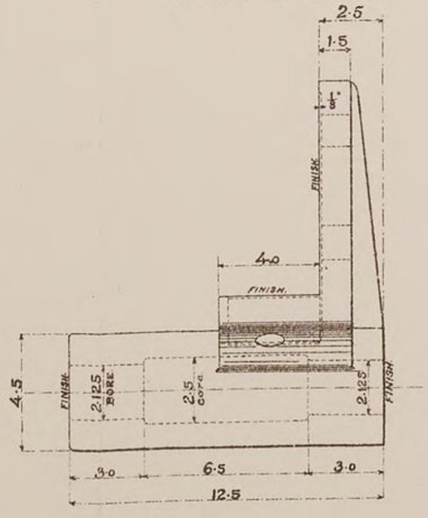












Approved:
D W Flagler
Brig. Gen. Chief of Ordnance

Barbette Carriage for 8 inch B.L. Rifle.

— Elevating Apparatus for Projectile. —

Developement of teeth for Mitres

Developement of teeth for Worm and Worm Wheel. 1·5 pitch

— Arm. —
One — a Set. — Wrot Iron. —

Shaft.
One — a Set Forged Steel.

Worm Wheel (Segmental)
One of this — a Set.
— Bronze. —

Worm & Shaft.
One of each — a Set.
— Forged Steel —

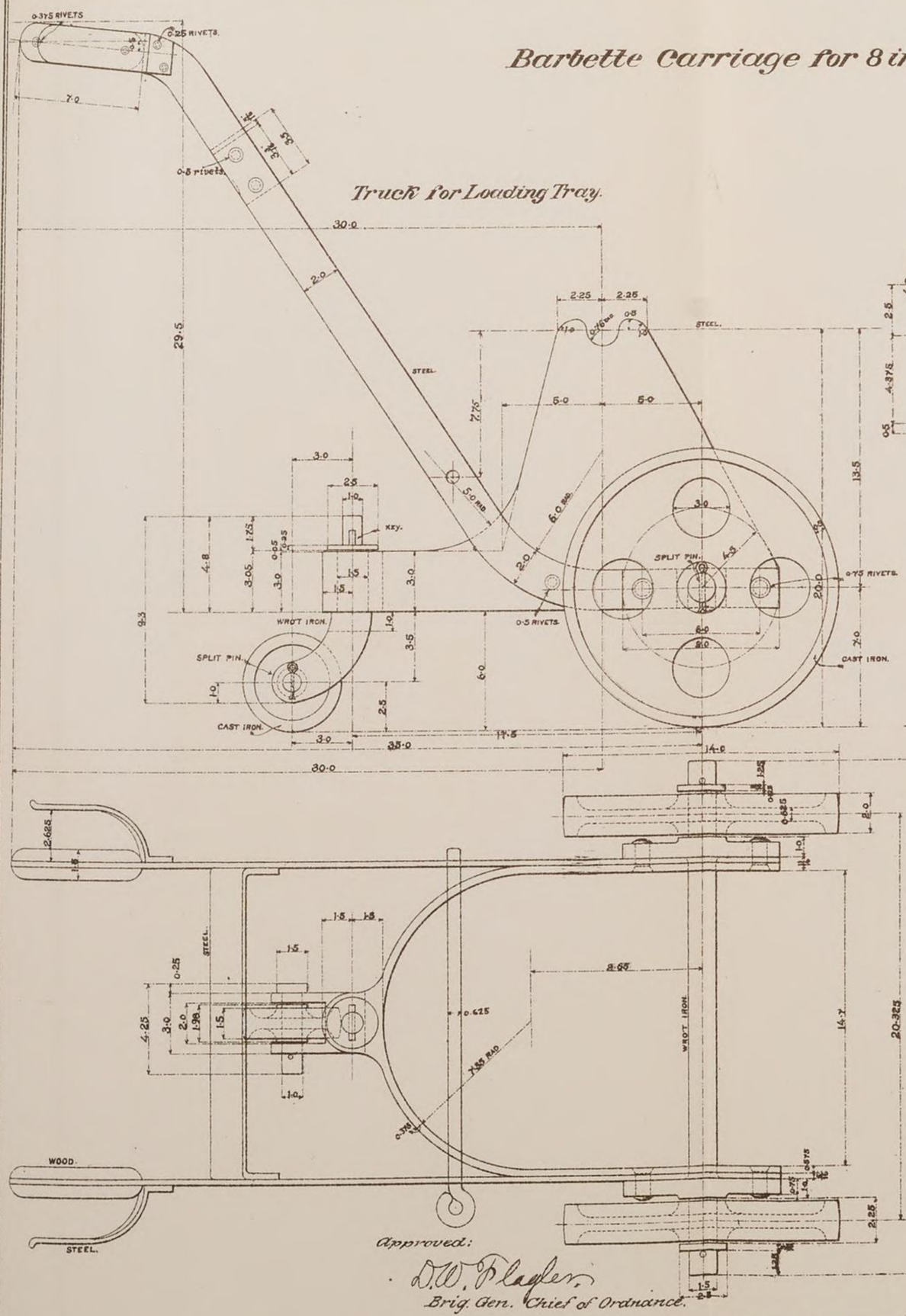
Mitres.
2 — a Set Bronze —
15 teeth. 1·25 Pitch.

Crank Shaft.
One — a Set. — Forged Steel —

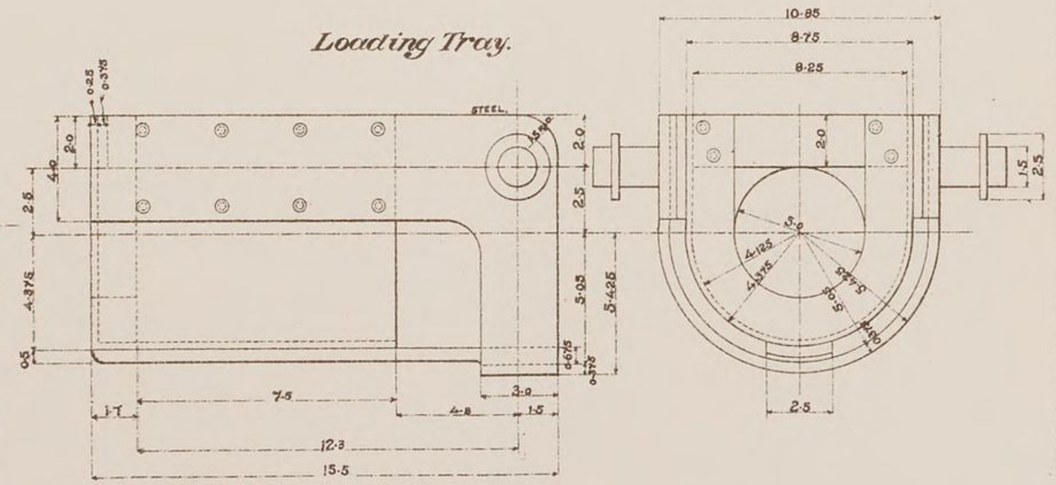
Approved
D W Flagler.
Brig. Gen. Chief of Ordnance

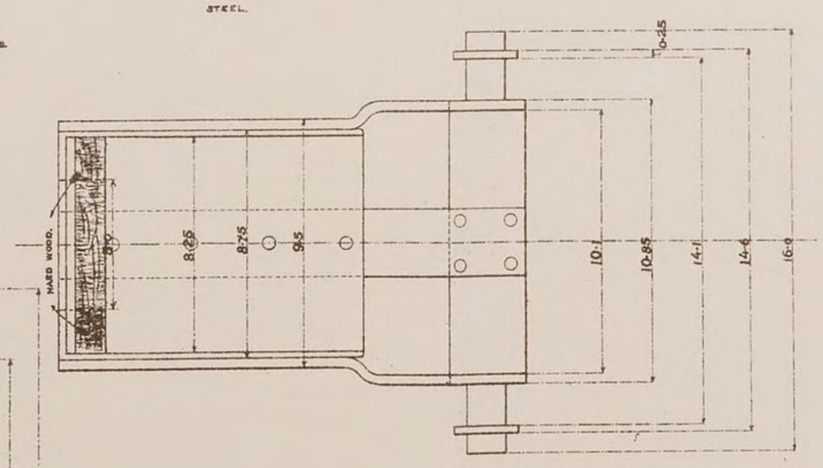
Barbette Carriage for 8 inch B.L. Rifle.

Truck for Loading Tray.

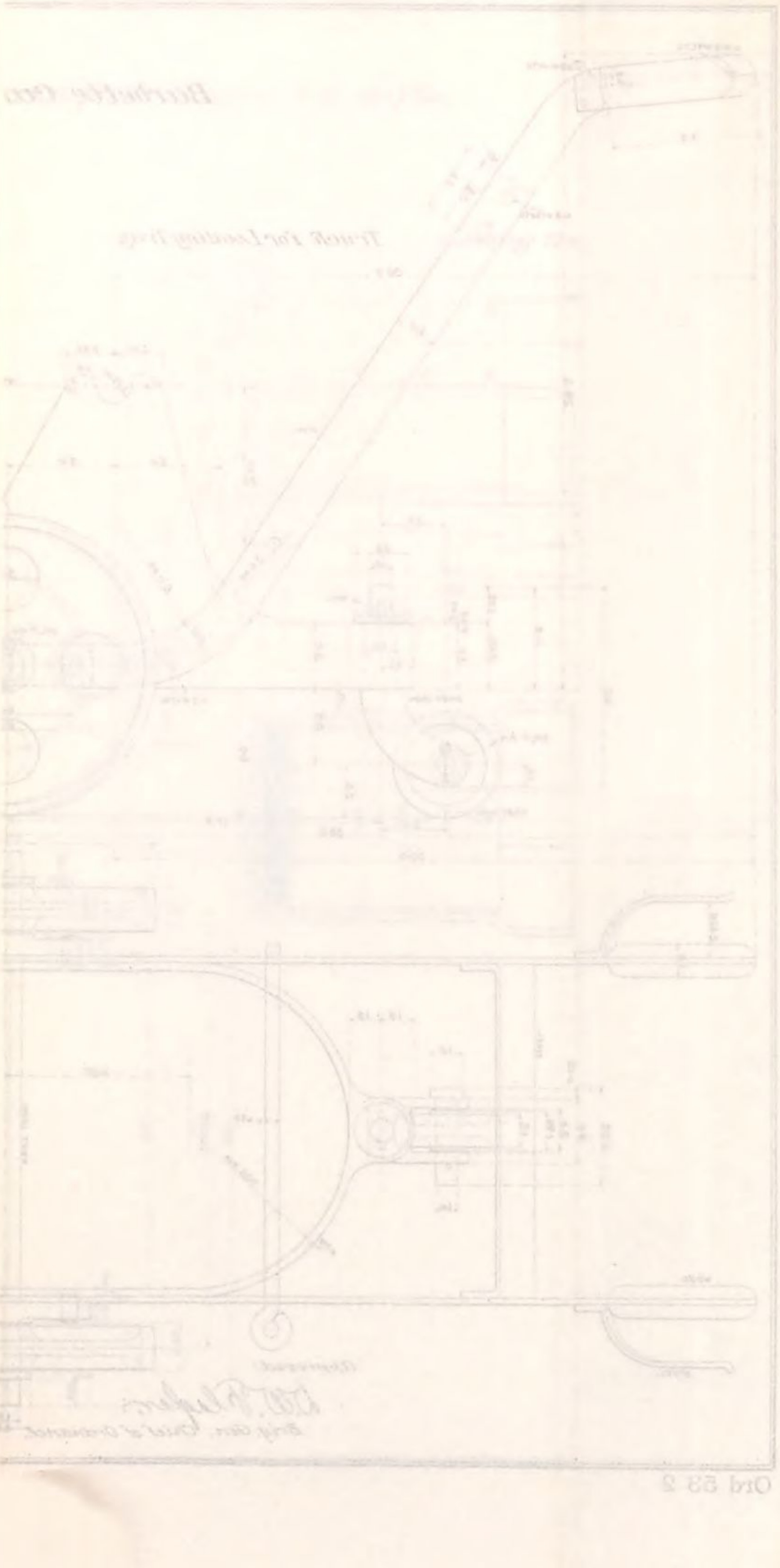


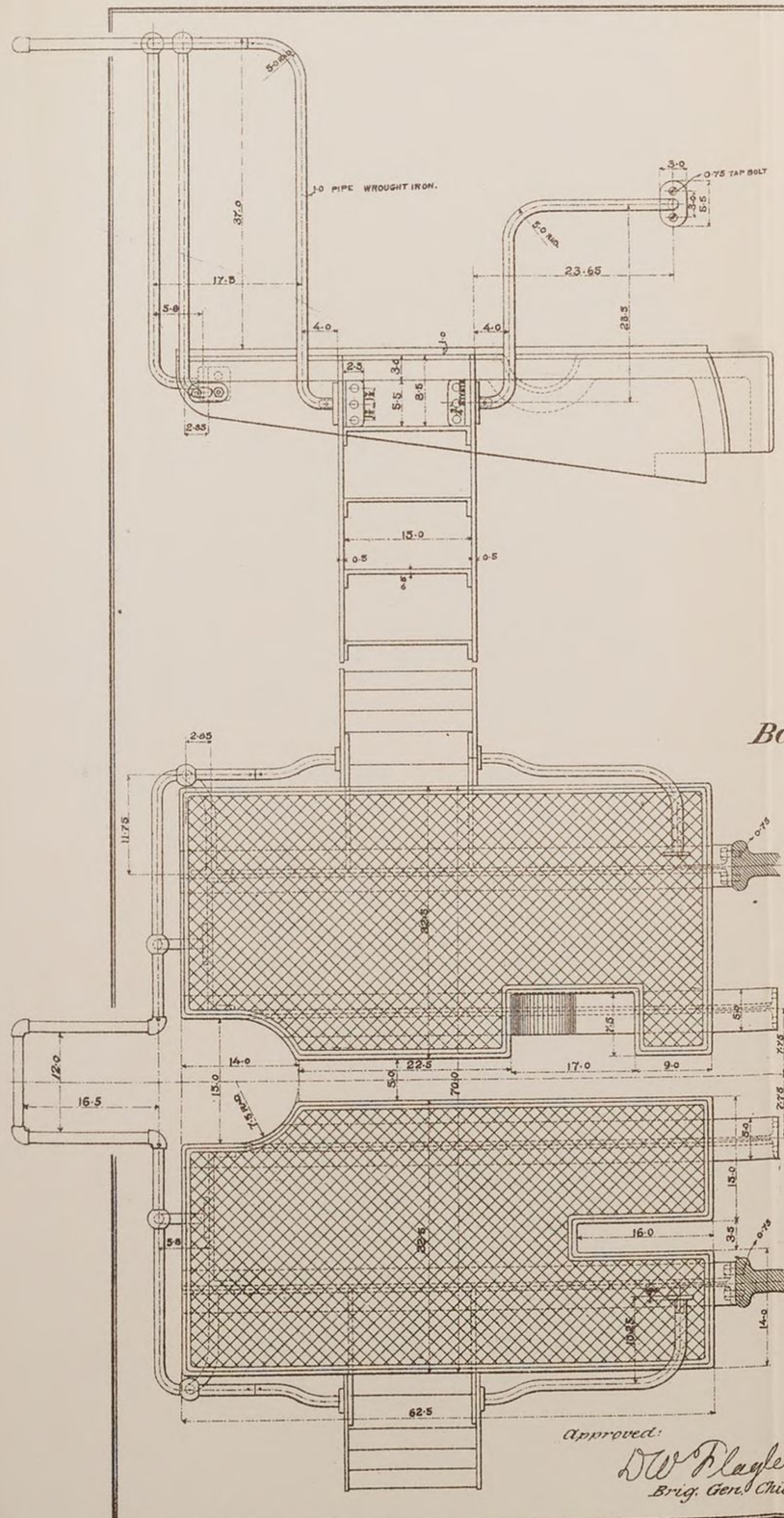
Loading Tray.

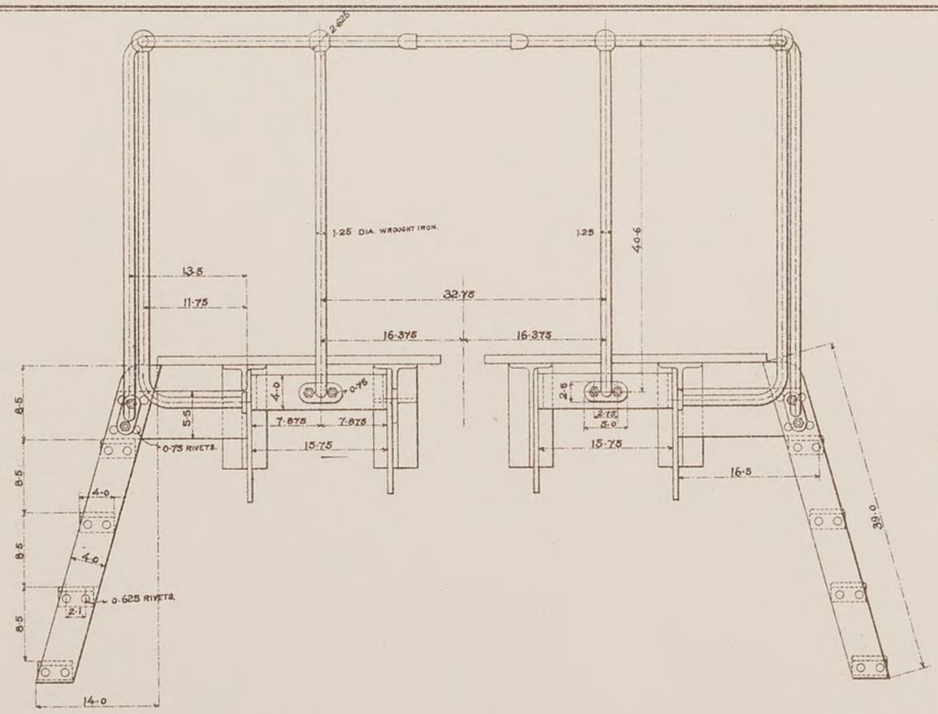




Approved:
D. W. Flagler.
Brig. Gen. Chief of Ordnance.

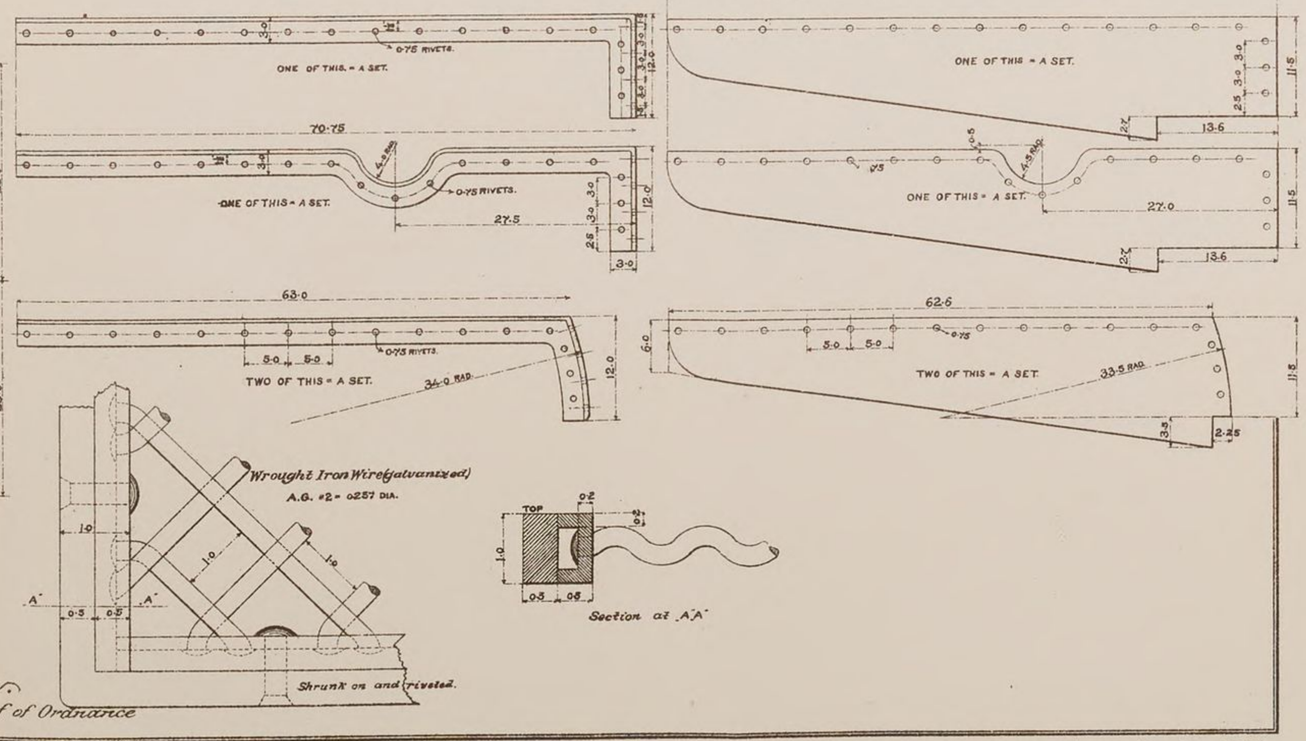






Barbette Carriage for 8 inch B.L. Rifle.

Platform.



Approved:

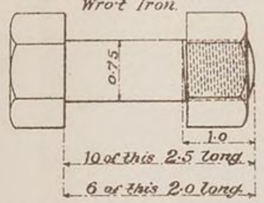
D W Flagler.

Brig. Gen. Chief of Ordnance

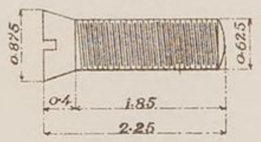
Barbette Carriage for 8 inch B.L. Rifle.

— Bolt List. —

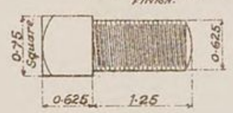
Railing to Chassis.
Wrot Iron.



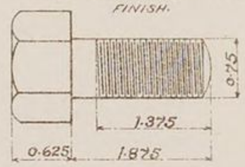
Bronze Bushing to Chassis.
4 = a Set. Forged Steel.
FINISH.



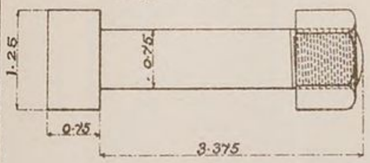
Collars to Crank Shaft.
4 = a Set. Forged Steel.
FINISH.



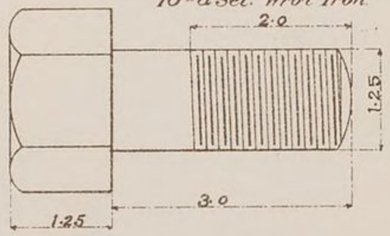
Railing to Chassis
4 = a Set. Forged Steel.
FINISH.



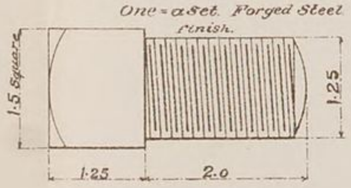
Platform Braces to Chassis.
16 = a Set.
Forged Steel.



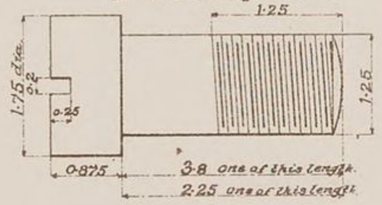
Bracket for Guide Wheel.
Support to Chassis.
10 = a Set. Wrot Iron.



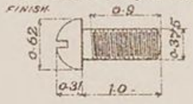
For Elevating Projectile.
One = a Set. Forged Steel
Finish.



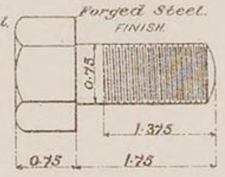
Elevating Rack to Gun
2 = a Set. Forged Steel.



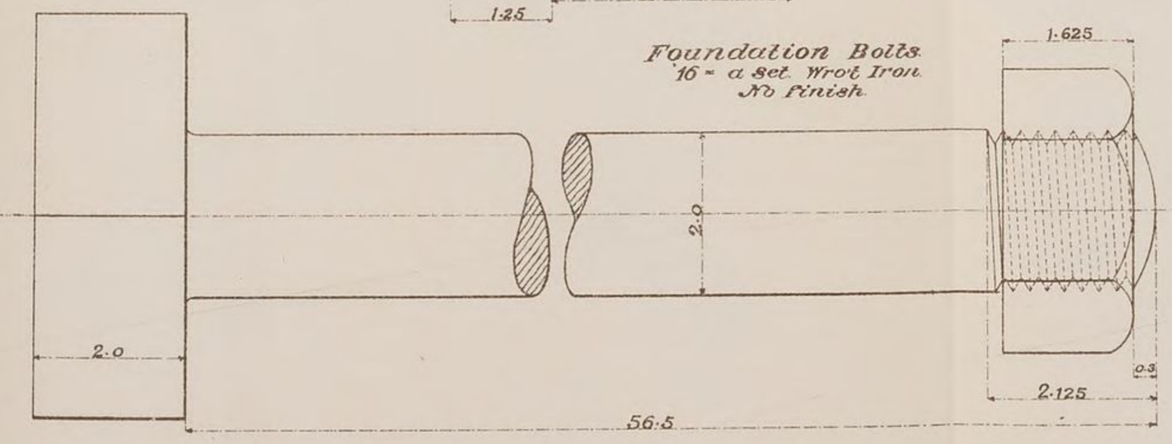
Dust Cover to Chassis.
36 = a Set. Forged Steel.
FINISH.

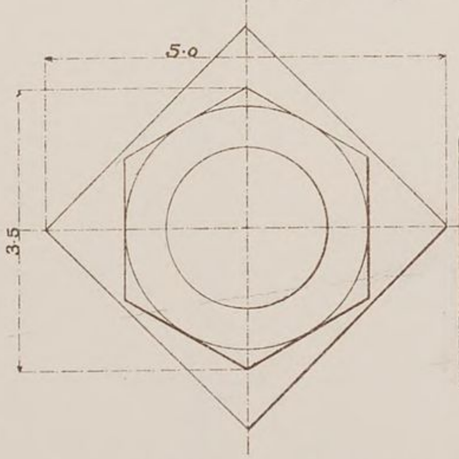


Platform Braces to Chassis.
16 = a Set
Forged Steel.
FINISH.

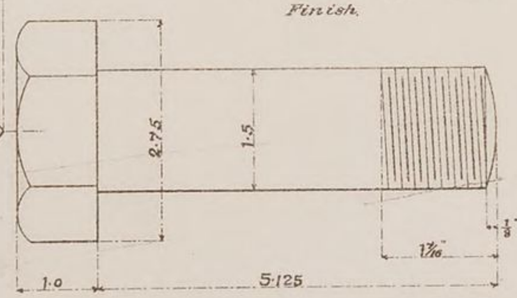


Foundation Bolts
16 = a Set. Wrot Iron
No Finish.

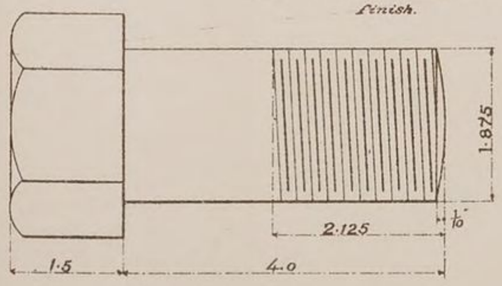


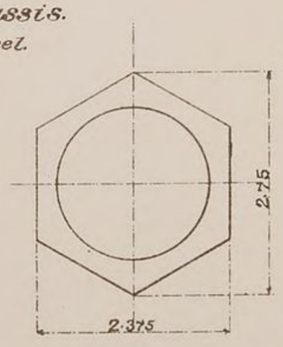


Guide Wheel to Support.
2 = a Set. Forged Steel
Finish.

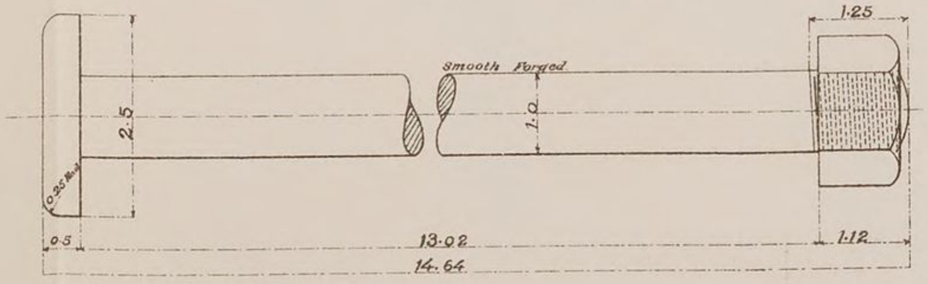


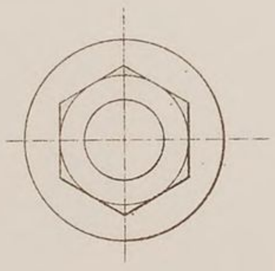
Guide Hooks to Chassis.
20 = a Set. Forged Steel.
Finish.



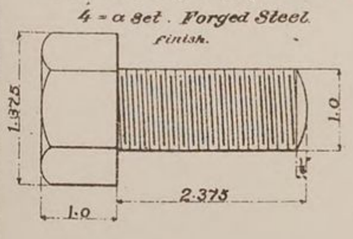


Braces to Distance Rings
10 = a Set. Wrot Iron NO FINISH

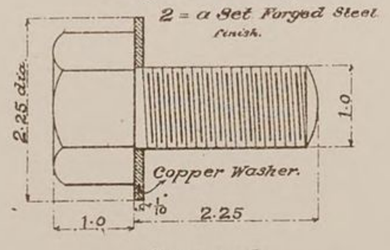




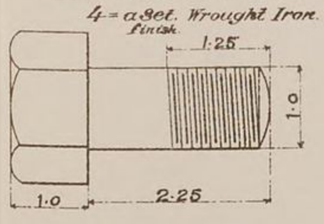
Trunnion Cap to Top Carriage.
4 = a Set. Forged Steel.
Finish.



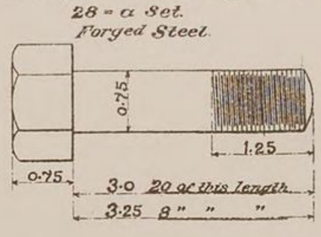
Plug for Filling Holes.
2 = a Set Forged Steel
Finish.



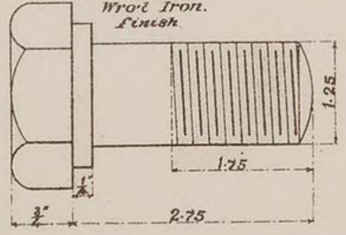
Elevating Brackets to Chassis
4 = a Set. Wrought Iron.
Finish.



Throttling Bars to Cylinder
28 = a Set.
Forged Steel.



Bracket for Guide Wheel
Support to Chassis.
2 = a Set.
Wrot Iron.
Finish.



Approved:
D W Flagler.
Brig. Gen Chief of Ordnance.

Barbette Carriage for 8 inch B.L. Rifle.

— Weight 55418 Lbs. —

Nomenclature, Principal Dimensions & Weights.

No.	Name of Parts.	Dimensions. Length	Breadth	Thickness	Diameter	Height	Material	Weight.	Remarks.
1	Top Carriage.	60.0	70.5	Cylinder 2.0 Cheeks. 2.5	Cyl. Bore. 8.5	39.65	Cast Steel	6620 lb	Plate 1.
1	Chassis.	123.85	96.75			68.1	Cast Iron	19000 "	" 2.
1	Bottom Roller Path.				128.0	29.5	" "	19850 "	" 3.
1	Worm Elevating Apparatus	7.0			Pitch dia 4.75		Forged Steel	36"	" 4.
1	Worm Wheel " "			2.25	Pitch dia 12.73		Bronze	49"	" 4.
1	Pinion " "			1.875	Pitch dia 5.968		Forged Steel	13"	" 4.
1	Rack " "			1.875	Pitch Rad 38947		" "	50"	" 4.
1	Shaft for Worm " "	24.9			2.0		" "	22"	" 4.
1	" " " Wheel" "	21.625			2.0		" "	20"	" 4.
1	" " Mitres " "	90.0			2.0 dia 1.5 Square		" "	75"	" 4.
1	" " Hand Wheels" "	80.0			2.1		" "	73"	" 4.
2	Collars " "			1.25	4.0		Wrt Iron	7"	" 4.
4	Mitres " "				Pitch dia 4.775		Bronze	32"	" 4.
3	Hand Wheels " "			1.2	17.00		"	104"	" 4.
1	Friction Clamp " "			1.875	10.805		"	23"	" 4.
2	Bushings " "	8.5			3.5		"	50"	" 4.
1	Front Bearing " "	4.0				7.0	Wrt Iron	30"	" 5.
1	Rear Bearing " "	4.0				9.0	"	40"	" 5.
2	Piston Rods.	79.5			32.5		Forged Steel	340"	" 5.
2	" Heads			3.0	8.49		" "	90"	" 5.
16	Recoil Rollers with Bronze Bushing.	4.48			8.00		" "	864"	" 5.
16	Journals for Recoil Rollers.	8.0			2.00		" "	112"	" 5.
2	Nuts for Piston Rods.			2.75	3.0		" "	34"	" 5.
2	" " " "			2.0	3.0		" "	28"	" 5.
2	Stuffing Boxes (Bushing Gland Follower						Bronze	280"	" 5.
2	Rear Cylinder Counter Recoil Buffer Covers with Bronze			6.0	12.5		Cast Steel	252"	" 5.
4	Throttling Bars - Recoil Brake	48.5	1.7023	1.5			Forged Steel	120"	" 6.
1	Journal for Worm Wheel Trav Apparatus	30.25			3.0		" "	84"	" 7.
1	Cranks Shaft. " "	70.0			2.5		" "	85"	" 7.
2	Cranks with Handles" "	18.0					Wrt Iron	40"	" 7.
2	Guide Wheels. " "			2.48	5.0		" "	28"	" 7.
2	Bolts Chain Connection" "	11.25			1.5		Forg'd Steel	16"	" 7.
1	Worm. " "	8.0			Pitch dia 6.618		" "	72"	" 7.
1	Worm Wheel " "			2.25	Pitch dia 18.382		Bronze.	122"	" 7.
1	Sprocket Wheel " "			2.75	12.9		Cast Iron	61"	" 7.
2	Supports for Guide Wheel" "	25.77	5.0	3.0	2.125		Wrt Iron.	88"	" 8.
2	Distance Rings. " "			1.0	35.24 47.20	4.0	" "	580"	" 8.
10	Braces. " "	11.02			2.05		Cast Iron	130"	" 8.
2	Brackets " "	14.25	10.0		14.5	12.5	" "	162"	" 8.
20	Conical Rollers " "	13.48			7.6652		Forged Steel	2300"	" 8.
4	Guide Hooks.		10.89	2.0		20.8	" "	562"	" 8.
1	Shaft Elevating App for Projectile	55.0			2.5		" "	82"	" 9.
1	Crank Shaft " " "	97.5			2.0		" "	90"	" 9.
1	Worm Shaft " " " "	15.35			2.042/125		" "	15"	" 9.
1	Worm. " " " "	7.0			Pitch dia 5.7		"	39"	" 9.
1	Worm Wheel (Segmental) " "			2.25	Pitch Rad 12.0		Bronze.	82"	" 9.
2	Mitres. " " " "				Pitch dia 5.968		"	20"	" 9.
1	Arm " " " "	50.75					Wrot Iron.	182"	" 9.
2	Cranks with Handles. " "	18.0					" "	40"	" 9.
1	Truck for Loading Tray (Complete)						Steel. Wrt Iron Cast Iron.	168"	" 10.
1	Loading Tray.	18.05	16.0			9.425	Steel	58"	" 10.
1	Platform (Complete)						Wrt Iron Steel	1014"	" 11.
197	Bolts.						Wrot Iron Steel	1084	" 12.

Bill of Material.

No	Name of Parts.	Dimensions. Inches.	Material.
2	Piston Rods.	79¾ × 3½ diameter	Forged Steel No 3
2	" Heads.	3½ × 8¾ "	" " "
16	Recoil Rollers.	4⅝ × 8½ "	" " "
16	Journals for Recoil Rollers.	8½ × 2½ "	" " "
1	Pinion. Elevating Apparatus	2½ × 7 "	" " "
1	Shaft " "	22 × 2½ "	" " "
1	Worm " "	7½ × 5¾ "	" " "
1	Worm Elev. App for Projectile.	7½ × 7 "	" " "
1	Worm. Trav. Apparatus.	8½ 8 "	" " "
20	Conical Rollers.	13¾ × 8 "	" " "
1	Nuts for Piston Rods	2⅞ × 6½ × 30	" " "
1	Rack Elev. Apparatus	5 × 5 × 24	" " "
1	Guide Hooks.	5½ × 11½ × 60	" " "
1	Shaft for Hand Wheels Elev. App.	80½ × 2⅜ diameter	Forged Steel No 2
1	Shaft for Mitres " "	90½ × 2½ "	" " "
1	Shaft for Worm " "	25½ × 2½ "	" " "
1	Crank Shaft Elev App for Projectile	98 × 2½ "	" " "
1	Worm Shaft " " " "	15⅞ × 2⅜ "	" " "
1	Crank Shaft Trav App	70½ × 2½ "	" " "
1	Journal for Worm Wheel.	14 × 6½ "	" " "
1	For Batt.	80 × 3 "	" " "
1	" "	40 × 2 "	" " "
1	" "	60 × ¾ "	" " "
4	Throttling Bars.	1¾ × 2 × 48⅝	" " "
1	Shaft. Elev App for Projectile	3 × 3 × 48	" " "
1	For Loading Tray.	3 × 12 × 14	" " "
1	" " "	18 × 2½ × ⅜	" " "
1	Truck for Loading Tray	128 × 2 × 5/16	" " "
1	" " " "	24 × 2 × 5/16	" " "
1	For Loading Tray.	15 × 24 × ¼	Forged Steel No 1
2	Truck for Loading Tray.	15 × 24 × 9/16	" " "
1	Dust Guard.	15½ × 55 × 15/100	" " "
1	" "	15½ × 90 × 15/100	" " "
2	" "	15½ × 66 × 15/100	" " "
2	Cheeks for Platform.	15½ 65 ⅜ thick	" " "
2	" "	15½ 71 ⅜ thick	" " "
2	Tees " "	⅜ × 86"	" " "
2	" " "	⅜ × 92"	" " "
1	Distance Ring	230 × 4 × 1¼	Wrought Iron
1	" "	306 × 4 × 1¼	" "
1	Chain Trav. Apparatus	Links 3"×2"×⅝" Length 350	" "
2	Wire Nettings for Platform	See drawing	" galvanized "
1	Equalizing Pipe (Hydraulic)	½ inside dia ⅝ outside dia 48 long	Copper
	7000 pounds.		Cast Steel.
	48000 pounds.		Cast Iron.
	2100 pounds.		Wrought Iron. (Scrap)
	1500 pounds.	88 Copper = 1320 pounds 12 Zinc = 180 "	Bronze.

approved:
D. D. Flagler
Brig Gen Chief of Ordnance

APPENDIX 29.

REPORT OF PRINCIPAL OPERATIONS AT THE ORDNANCE PROVING GROUND, SANDY HOOK, N. J., FOR THE YEAR ENDED JUNE 30, 1893.

(2 plates.)

SANDY HOOK PROVING GROUND, *July 20, 1893.*

SIR: I have the honor to submit the following report of the principal operations of this post during the fiscal year ended June 30, 1893:

During the year experimental firings and tests have been conducted daily whenever the weather and other circumstances would permit. The object of the firings and the extent and character of the work done at the proof batteries may be ascertained by an inspection of the following tables, viz:

Table I.—Rapid-fire guns.
Table II.—Field and siege guns.
Table III.—Mortars.
Table IV.—Seacoast guns.

INCREASING FACILITIES FOR CONDUCTING EXPERIMENTS.

The number and variety of firings conducted during the fiscal year for experimental and proof purposes have been greater than during any other year of the history of this proving ground.

Considerable progress has been made in the enlargement of the resources of the post to meet the demands that may be made upon it. The principal work done in this connection is the building of two large firing butts capable of stopping projectiles fired from the heaviest modern guns; clearing the Gantry runway and grading the grounds in its vicinity; building platforms for 8 and 10 inch Buffington-Crozier disappearing carriage, 4.7-inch Armstrong rapid-fire gun and carriage, and platform for the Brown segmental wire gun. The capacity of the machine and carpenter's shop has been increased by the introduction of wood-working machinery and a new engine and boiler. The wharf pertaining to the post has been improved by rebuilding its outer end and strengthening its approach, so that guns of 12-inch caliber or under can be safely transported over it.

FIRING BUTTS.

The firing butts now used at this place are clearly shown in the accompanying Pl. A. The design is the result gained from experience of the requirements of a butt which will stop projectiles from any gun, and admit of the projectiles being recovered with the least possible expenditure of time and labor. The difficulties heretofore experienced

resulted from the fact that the revetment was quickly carried away, necessitating the practical renewal of the butt after a few rounds. As may be seen from the drawing, the present butt is now built with an opening, 10 feet by 7 feet, which opening is roofed over for a distance of 6 feet back from the main revetment. Into this opening the projectiles are fired, and it was hoped that the natural fall of the sand would be sufficient to stop them. Trials, however, showed that with this slope of sand the projectiles were deflected upwards, and that an undue height of butt would be required to properly stop them. The opening was therefore cheaply revetted with 3-inch boards and filled with sand, by which means the projectile was made to pass much farther into the body of the sand than before. The butt, as finally constructed, answers every purpose, and for the conditions existing at this place can scarcely be improved.

SHOP IMPROVEMENTS.

The capacity of the carpenter shop has been increased by the erection of the following wood-working machinery, viz:

One band saw, Berry & Orton, No. 1, complete.
One lathe, wood-turning, 25 by 11 inches.
One mortiser and borer complete, with 5 chisels and 5 bits.
One saw table, complete with boring attachment, cross-cut carriage, and three saws.
One wood-boring machine, "Ajax."

The increased demand for engine power required by these machines, together with the fact that the engine and boiler on hand had become unserviceable from long and constant use, rendered a new engine and boiler an absolute necessity. For this purpose the Fifty-second Congress, at its first session, appropriated the sum of $2,000. With this amount were purchased a 25-horse-power engine and a 40-horse-power boiler. The engine is the Putnam patent improved automatic cut-off steam engine, manufactured by the Putnam Machine Company, of Fitchburg, Mass. The cylinder is 9 inches diameter and 21 inches stroke. The fly-wheel is 7 feet diameter, 13 inches face, and turns 85 revolutions per minute. The boiler is of the horizontal tubular type, procured under contract with Messrs. H. N. Bates & Co., Boston, Mass. It is of first-class workmanship and material, and provided with all appliances, including a duplex improved steam pump and Jacobs' feed-water heater.

REBUILDING AND STRENGTHENING WHARF.

The outer extremity of the wharf pertaining to this post had so deteriorated by use and long exposure as to become entirely unserviceable. This portion (98 by 33 feet) has been rebuilt in accordance with plans and specifications prepared under my direction by Lieut. C. B. Wheeler, Ordnance Department. These plans and specifications were prepared after an exhaustive study of the subject, and are believed to be worthy of publication as a guide in connection with future constructions of a similar character that may be required at other arsenals. They are appended marked Pl. B, Specification C. The work was done under contract with Henry Du Bois' Sons, of New York City, and great credit is due both to designer and contractor for the very satisfactory results obtained.

The approach to the wharf for a distance of 380 feet has been strengthened, so that all weights up to that of a 12-inch rifle can be safely transported over it. The work consisted in renewing all caps and other pieces showing signs of weakness, in placing bents between the existing piers of the approach, thus materially reducing the space between any two supports. For the first four openings between piers the bents were made of piles capped with 12 by 12 inch yellow-pine timber. All others were made of yellow-pine timbers secured to timber foundations placed directly on the sand. Heretofore it has been necessary in receiving 10 and 12 inch guns to beach them at low tide, and haul them up by means of cradles, rollers, and a capstan. They can now be placed on cars on the wharf and hauled direct to the firing battery.

RAILROAD TRANSPORTATION.

During the fiscal year the railroad tracks, sidings, frogs, and switches (about 6 miles of track), situated on the United States reservation at this place, have been purchased of the Central Railroad Company of New Jersey, and are now available for Government use by the Department. To utilize to the fullest extent the advantages resulting from this purchase this railroad should be connected with the Gantry runway at the main firing battery by a branch beginning at a point on the main road in the vicinity of the 3,000-yards target and passing up the beach to the battery. In this way heavy guns and carriages could be delivered at the firing battery on cars direct from the place of manufacture at a great saving in labor and cost for transportation.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ord. Dept., U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4018–'93.)

TABLE I.—*Rapid-fire guns.*

Object of firing.	6-pounder Hotchkiss.	6-pounder Driggs-Schroeder.	6-pounder Seabury.	4.7-inch Armstrong.	Total.
Test of gun	.....	.....	.....	12	12
Test of Armstrong combination fuse	.....	.....	.....	2	2
To determine velocity	10	12	13	.....	35
Proof of powder	.....	11	.....	.....	11
Troisdorf smokeless powder	.....	1	.....	.....	1
Test of breech mechanism	.....	.....	8	.....	8
Total rounds for gun	10	24	21	14	.....

TABLE II.—*Field and siege guns.*

Object of firing.	2.75-inch B. L. Armstrong.	3-inch M. L. wrought iron.	3-inch B. L. Hotchkiss.	3.2-inch B. L. service.	3.2-inch B. L. Gerdom.	3.2-inch B. L. Driggs-Schroeder.	3.6-inch B. L. service.	5-inch B. L. Seabury.	5-inch B. L. service, No. 4.	7-inch B. L. howitzer, No. 1.	7-inch B. L. howitzer, No. 4.	Total rounds for object of firing.
Test of—												
Electric welded shrapnel	....	....	....	142	....	....	....	....	....	....	....	142
Frankford Arsenal shrapnel	....	....	....	17	....	....	28	....	....	....	....	45
Hotchkiss shrapnel	....	....	41	48	....	....	....	....	....	....	....	89
Walter fuse	....	....	....	13	....	....	....	....	....	....	....	13
Driggs fuses	....	....	....	20	....	....	....	....	....	....	....	20
Frankford Arsenal fuses	....	....	....	19	....	....	....	....	....	....	....	19
Best sight	....	....	....	14	....	....	....	....	....	....	....	14
Carbaugh sight	....	....	....	50	....	....	....	....	....	....	....	50
Proof of—												
Troisdorf smokeless powder	....	....	....	23	56	....	....	3	....	....	....	82
Powder	....	95	....	12	....	....	11	19	....	....	....	137
Leonard's smokeless powder	....	....	....	....	37	....	....	....	....	....	....	37
Navy smokeless powder	....	....	....	....	6	....	....	2	....	....	....	8
Powder in water-proof cases	....	....	....	218	....	....	....	....	....	....	....	218
Using gravity chronograph	....	....	....	48	....	....	....	....	....	....	....	48
Test banding of projectiles	....	....	....	15	....	....	....	....	....	....	....	15
With axial vent	....	....	....	12	....	....	....	....	....	....	....	12
Testing—												
Cartridge cases	....	....	....	....	....	24	....	....	....	....	....	24
Breech mechanism, Gerdom	....	....	....	....	104	....	....	....	....	....	....	104
Exhibition before Secretary of War	....	....	....	4	1	....	....	....	....	2	....	7
Range table	....	....	....	70	....	....	....	....	....	....	....	70
Trial of elevating apparatus	....	....	....	20	....	....	....	....	....	....	....	20
Test of Allen's high explosive	25	....	....	....	....	....	....	....	....	....	....	25
Trial of Seabury breech mechanism	....	....	....	....	....	....	....	20	....	....	....	20
Test the influence of position of band on the accuracy of fire	....	....	....	....	....	....	54	58	....	22	....	134
Raskazoff disappearing carriage	....	....	....	....	....	....	....	3	....	....	....	3
Proof of gun	....	....	....	....	....	....	....	....	7	....	7	14
Test of—												
Carriage	....	....	....	....	....	....	....	....	....	90	....	90
Gun for endurance	....	....	443	....	....	....	....	....	....	....	....	443
Gun for accuracy	....	....	9	....	....	....	....	....	....	....	....	9
Griswold percussion fuse	....	....	....	....	....	....	2	....	....	....	....	2
Total rounds for guns	25	95	493	745	204	24	95	105	7	114	7	.....

TABLE III.—*Mortars.*

[Items in black figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	8.6-inch steel.	12-inch cast-iron, Builders' Iron Foundry.	12-inch cast-iron, South Boston.	12-inch steel, Watervliet.	12.2-inch cast-iron, South Boston.	Total rounds for object of firing.
Test of—						
Frankford percussion fuse	9	.....	.....	.....	.....	9
Frankford combination fuse	20	.....	.....	.....	.....	20
Gun for endurance	.....	.....	.....	**32**	.....	32
Spiral springs	.....	6	.....	4	.....	10
Canét carriage	.....	5	.....	.....	.....	5
Spring return carriages	.....	{ 4 / **10** }	.....	15	.....	29
Wheeler Sterling steel shell	.....	8	.....	.....	.....	8
Bethlehem steel shell	.....	1	.....	.....	.....	1
Steel shell	.....	.....	.....	.....	2	2
Easton and Anderson carriage	.....	.....	17	.....	.....	17

TABLE III—*Mortars*—Continued.

[Item in black figure shows that the round was fired with two objects. This round is not counted in the total for gun.]

Object of firing.	3.6-inch steel.	12-inch cast-iron, Builders' Iron Foundry.	12-inch cast-iron, South Boston.	12-inch steel, Watervliet.	12.2-inch cast-iron, South Boston.	Total rounds for object of firing.
Experiments with high explosives					5	5
Exhibition before Secretary of War	1		2			3
To determine velocity	36	7			4	47
Proof of—						
Gun		94				94
Powder		5 5		13		28
To determine range and observe flight of shell		3				3
Exhibition before Board of Ordnance and Fortification			2			2
Total rounds for guns	66	133	21	32	11	

TABLE IV.—*Seacoast guns.*

[Items in black figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	5-inch Brown segmental.	8-inch M. L. smooth-bore.	7-inch M. L. wrought iron.	8-inch steel, West Point.	8-inch steel, W. A., No. 4.	8-inch steel, W. A., No. 1.	10-inch steel, W. A., No. 6.	10-inch steel, W. A., No. 1.	12-inch cast-iron, tubed.	12-inch cast-iron, hooped and tubed.	12-inch steel, W. A., No. 1.	11-inch M. L. converted rifle.	Total rounds for object of firing.
Proof of powder	13	....	....	....	....	14	....	19	....	....	41	....	87
Test of—													
Leonard's smokeless powder	4	....	....	....	....	....	....	....	....	....	....	....	4
Gun for endurance	2	....	....	....	....	....	....	....	12	....	....	....	14
Proof of gun	....	....	....	37	7	....	8	....	....	7	....	....	59
Test of gasoline shell	....	2	....	....	....	....	....	....	....	....	....	....	2
Experiments with high explosives	....	....	27	....	....	....	....	....	....	....	....	6	33
Test of—													
8-inch barbette carriage	....	....	....	8	....	22	....	....	....	....	....	....	30
Breech mechanism	....	....	....	1	....	....	....	....	....	....	....	....	1
11¼-inch armor plate	....	....	....	....	....	....	1	3	....	....	....	....	4
French smokeless powder	....	....	....	....	....	....	....	....	....	....	1	....	1
Schneider-Creusot carriage	....	....	....	....	....	....	....	....	....	3 10	....	....	13
Exhibition before Secretary of War	....	....	....	....	....	1	....	1	....	....	....	....	2
Test of—													
Pneumatic disappearing carriage	....	....	....	....	....	....	....	30	....	....	....	....	30
Gordon disappearing carriage	....	....	....	....	....	....	....	13	....	....	....	....	13
German smokeless powder	....	....	....	....	....	7	....	....	....	....	....	....	7
Determine drift of projectile	....	....	....	....	....	10	....	....	....	....	....	....	10
Test gun for accuracy	....	....	....	....	....	....	....	....	13	....	....	....	13
Total rounds for guns	19	2	27	38	7	54	9	66	25	7	45	6	....

SPECIFICATIONS FOR THE REMOVAL AND CONSTRUCTION OF A DOCK FOR THE UNITED STATES ORDNANCE DEPARTMENT AT SANDY HOOK, N. J.

The present dock, including all timber and pile work, will be removed for a distance of about 98 feet from the end. All the old piles will be pulled up. All the old material to remain the property of the Ordnance Department. The new dock will be constructed of sound yellow pine sawed timber, unless otherwise specified, and all bolted with wrought iron.

The dock will be built on vertical and braced with inclined piles, with arrangement of timbers as shown by the drawings.

The rows will be spaced 10 feet from center to center, and the piles in each row so placed as to make the four outside spaces 6 feet 4 inches from center to center, and the middle space 8 feet from center to center. All the rows are to be set at right angles to the sides of the dock. The two outer rows will have each two inclined piles, and on each side of main gangway there will be one inclined pile. All the other rows, except the two nearest the inshore end, will have one inclined pile each, as shown in the drawings. The piles will all be firmly braced and capped.

THE SUPERSTRUCTURE.

The superstructure over the piles is to consist of two side caps, two side ranges, and four intermediate ranges, all of 12 by 12 inch stuff, with 6 floor beams of 6 by 12 inch stuff, all as shown in the drawings. There will be a deck of 4-inch plank with backing logs, chocks, mooring, and fender piles, etc., all as hereinafter specified and as shown upon the drawings.

GRADE.

The level of the 4-inch deck of the dock will be about 5 feet 4 inches above mean high water and the same height as that of the existing dock to which it is to be joined.

SUBSTRUCTURE.

PILES.

The vertical and bracing piles of the dock, 86 in number, will be of sound and straight yellow pine, white pine, or cypress, and all of sufficient length to bring up in driving according to the specifications for pile-driving, hereinafter contained, to the satisfaction of the commanding officer or officer detailed by him in charge of the work. The vertical and bracing piles will not be less than 14 inches at the butt and 7 inches at the point; both measurements to be made under the bark. All the piles must be to the satisfaction of the commanding officer or the officer detailed by him in charge of the work.

DRIVING PILES.

Each vertical pile is to be driven with a hammer of at least 2,500 pounds weight, having a concave face, with an effective fall of 10 feet, or with a hammer and fall providing a blow of equal mechanical effect, to the satisfaction of the commanding officer, or officer detailed by him in charge of the work. It is to be driven to hard bottom, or until the last two blows of the hammer will not drive it more than a half inch, or as the commanding officer may direct. Each bracing pile will be driven to the same depth below mean low-water mark as the adjacent vertical piles are driven. The bracing piles may be drawn down so as to get the heads under the hammer, if it should be found necessary, but the piles will be sent home by driving, to the satisfaction of the commanding officer. The hammer will be allowed to fall in driving free and clear of its hoisting rope, if the commanding officer shall so direct. The heads of the piles will be protected against the blows of the hammer with a wrought-iron ring. If any piles are badly split in driving

The new dock will be about 98 feet long by 34½ feet wide, measured on a line at right angles to its length from outside of backing log to outside of backing log.

they will be replaced with others, or repaired with wrought-iron rings or screw bolts, as the commanding officer may direct.

The cross rows of piles will be straightened and stay-lashed as soon as the piles in one row are driven, and before they are tenoned. Any vertical or bracing pile that is driven down too low to cut off at the required grade will be removed, and another pile will be driven in its place. The contractor will not be allowed to pull it up to the required grade to make it available in the work.

CUTTING TENONS.

All the vertical bearing piles will be cut off accurately at the levels necessary to bring the 4-inch planking to proper grade, and each pile will have tenons cut upon them 7 inches in length, $3\frac{1}{2}$ inches in width, and 3 inches in height. The length of the tenon in each case will be cut parallel with the length of the cap, which is mortised to fit it as hereinafter specified.

Each tenon, mortise, and head of a pile will be covered with Wilmington tar or dead oil, as the commanding officer may direct.

SIDE CAPS.

A side cap of 12 by 12 inches, sawed yellow-pine timber, will be placed upon the piles along each side of the dock, and each cap will extend from the old dock to the outer end of the new dock. The cap will be accurately mortised to fit the tenons of the piles on which it bears.

The cap will be fastened at each bearing on a pile with one $\frac{7}{8}$-inch square by 22-inch dock spike driven at an angle.

The side caps will be constructed of pieces varying in length, as shown by the bill of materials. They will be joined by scarf joints hereinafter described, joints to come between rows of piles about as located in the drawings.

CROSS CAPS.

Every transverse row of piles will be capped with 12 by 12 inch sawed yellow-pine timber in single lengths, extending full width of dock, with ends bearing on side caps and cut off flush with outsides thereof. They will be accurately mortised to fit the tenons of the piles on which they bear. They will be fastened at each bearing on a pile with one $\frac{7}{8}$-inch square by 22-inch dock spike driven at an angle. Where the dock is wider than $34\frac{1}{2}$ feet two lengths may be used, joined by scarf joints as hereinafter described. Scarfs to come between piles.

HEADS OF PILES TRIMMED.

Where the head of any pile extends outside of the cap resting upon it, the projecting portion of the pile will be neatly dressed off from the line of the cap downwards for a distance of about 12 inches, and this trimmed surface will be freely treated with dead oil.

BRACE PILES.

The two outer rows of piles will be braced with two inclined piles each, and the main gangway with one on each side. Every other row will have one inclined pile except the last two inshore end. The piles

will be driven with an inclination of about a foot vertical to 8 inches horizontal. Each of these piles will be secured to the side and cross caps and to the second pile in each row with screw bolts 1⅛ inches in diameter, of the length required, each with two cast-iron washers. The heads will have a good bearing on the ride ranger and will be shouldered under the cross cap one or two inches, and will be chocked under the dock. The washers and screw bolts will be counter sunk where necessary. The brace piles on each side of the gangway will be brought to a firm bearing and bolted to adjacent piles, as shown in the drawings.

BRACING.

Each transverse row of piles will be braced with horizontal and A-braces of 5 by 10 inch yellow pine, as shown in the drawings. The cross ties will be placed with their centers at mean low water, and will be fastened to the outside piles of the rows against which they bear with ⅞-inch screw bolts, in lengths as required by the size of the pile, each with two washers, and will be fastened to each remaining pile of the transverse rows with one ¾ by 12 inch dock spike. The piles will be notched from 1 to 2 inches, as directed by the commanding officer, to give the bottom of the horizontal brace a good bearing against the thrust of the A-braces. Where the dock is 34½ feet wide these horizontal braces will be in one piece; where the dock is wider two pieces may be used. In this case both joints will be made only between piles with fish plates of 4 by 10 inch yellow pine, 3½ to 4 feet long, fastened with four ⅞-inch in diameter 12-inch screw bolts, each with two washers.

A-BRACES.

The A-braces, 5 by 10 inch yellow pine, will be placed as shown in the drawings, and will be in single lengths. Each piece will extend from the top of the cross cap to the top of the horizontal braces. They will be butted at the cross caps and will foot upon the top of the horizontal braces. The ends of these braces will be fastened to the cross caps with 1-inch diameter screw bolts, each with two washers and to the outside piles of each transverse row against which they bear with 1-inch diameter screw bolts with two washers, and in lengths required by the piles. At every remaining crossing with a pile they will be fastened with one ¾ by 12 inch dock spike. The butts of all the braces must be well fitted to secure a good bearing against thrust. The piles must be sided down for the width of the brace and suitable blockings may be used wherever it is necessary in order to give the brace a good bearing, as directed by the commanding officer.

SUPERSTRUCTURE.

MAIN GIRDERS.

There will be six main girders of 12 by 12 inch yellow pine over the piles on cross caps, spaced as shown on the drawings. They will vary in length as shown by the bill of materials and the drawings. Tney will be scarf-jointed as hereinafter described, the scarf in every case to come over a cross-cap bearing, and they will break joints as shown. They will be fastened at each bearing with one ⅞ by 22 inch dock spike driven in an angle.

INTERMEDIATE GIRDERS.

There will be six intermediate girders and seven of shorter length for triangular portion of dock of 6 by 12 inch yellow pine. They will be spaced and of lengths as shown in the drawings. They will be bolted together with $\frac{7}{8}$-inch bolts where they overlap each other at cross caps, and will be fastened at each bearing with one $\frac{3}{4}$-inch by 20-inch dock spike.

SCARFS.

The scarfs for all cross caps, side caps, and girders will be 4 feet in length. Each scarf will be fastened with two 1-inch in diameter screw bolts 14 inches long with washers, and will be additionally fastened with two $\frac{1}{2}$-inch square by 10 inch dock spikes. When required to leave a level bearing for timber or planking, the top of the timber will be countersunk to receive heads and washers of scarf screw bolts, and in these cases screw bolts will be shortened as required.

COUNTERSUNK HOLES.

All holes countersunk in the horizontal surfaces of the timbers to receive the heads of bolts will be filled in with melted pitch to the level of the surface of the timber after the bolts are in place.

DECK.

The whole of the new deck will be covered with 4-inch yellow-pine plank laid crosswise on the girders close together. No streak to be in more than two pieces; planks to be butted only at center of 12 by 12 inch girders, and joints to be well broken. Each plank will be spiked at every crossing with one, and at each butt with two $\frac{1}{2}$ by 9 inch spikes.

BACKING LOGS.

Backing pieces of 12 by 12 inch yellow-pine timber will be placed around both sides and end of dock and on sides of main gangway. They will be in lengths of not less than about 30 feet, with half-top joints 24 inches long, and corners half lapped. The backing logs will be fastened to planking and girders with $\frac{7}{8}$-inch square by 28-inch dock spikes, placed not more than 9 feet apart, with two spikes at each joint. Chocks for mooring piles and at the corners will be put in as shown in the drawings, and will be fastened by $\frac{3}{4}$-inch square by 16-inch dock spikes.

FENDER PILES.

An oak-fender pile, 12 inches in diameter under bark at 2 feet from butt and 6-inch point, will be well and solidly driven, to the satisfaction of the commanding officer, to protect each side and front pile with five at each corner and two on each side of main gangway. They will be cut off level with the top of the backing log and will be secured to it by 1-inch screw bolts with two iron washers of the lengths required, countersunk into the piles and into the backing log.

The corner clusters will be secured by one $\frac{1}{8}$-inch diameter screw bolts of the length required, each with two iron washers countersunk at each end, as shown on the drawings. The middle one and the two outside ones are bolted as shown, and the two intermediate ones are spiked to the backing log with dock spikes $\frac{7}{8}$ inch square by 18 inches.

CHOCKS.

The spaces between all fender piles on the three faces of the dock will be filled in at back log level with 8 by 10 inch yellow-pine chocks, the 10-inch face horizontal. The ends of the chocks will be dovetailed into the sides of the fender piles and will be fastened with four $\frac{3}{4}$-inch square by 20-inch dock spikes.

The top edge of all chocks will be beveled.

MOORING PILES.

There will be fine white-pine mooring piles driven in wharf, as shown by the drawings or as directed by the commanding officer. They will measure not less than 16 inches at butt, 8 inches at point, and be long enough to allow of their being driven well into the bottom, to the satisfaction of the commanding officer. Each pile will be screw bolted to the adjoining wharf timbers, chocked at cap or girder level, and well chocked on deck. A short girder will be inserted wherever necessary to support ends of plank cut by mooring pile. They will stand 4 feet above backing log, with tops smoothly rounded, and will be painted with two coats of white lead and oil.

GANGWAY.

An inclined gangway will be constructed at end of wharf, as shown. The front row of piles will have chocks between each pile at level of mean high water of 12 by 12 inch yellow pine, squared into piles for a distance of 1 or 2 inches and firmly spiked. The girders for the gangway will be of 6 by 12 inch yellow pine with 4-inch planking, and the gangway will be sided where necessary with 2-inch yellow pine. The two middle piles of the second row will be cut off at such a level as to permit of a short cross cap of 12 by 12 inch yellow pine, with blocks on top of the same dimensions, as shown, on which the main cross caps of row rest.

CONNECTIONS WITH OLD DOCK.

The cross caps on last row of piles will be firmly secured to ends of cross caps of old dock by wrought-iron straps, four in number. The straps will be about 4 inches wide, with 1-inch bolts and washers through new cap and $\frac{3}{4}$-inch bolts through strap.

QUALITY OF TIMBER.

All timber and planking must be of first quality Georgia or Florida yellow pine, free from windshakes, decay, knots, and other injurious defects. The cross sectional area of sap or wane or both combined must not exceed 1 square inch in the specified cross section of any piece of timber. What is known as North Carolina yellow pine will not be accepted.

FRAMING.

All framing must be of the best quality of workmanship. Mortises and tenons, scarfs, and other joints must be accurately fitted, equal in all respects to what is required for the best quality of bridge building, and must conform strictly to the requirements of the drawings. No blocking or chin pieces will be allowed to make good joints. The ends of all timbers, planks, etc., must be squared off with the saw; the ax

must not be used in such work. All mortises and tenons which come together must be of the same depth and will be nicely finished with the chisel or plane so as to fit accurately. All countersinking must be done with coaking augers; the ax or chisel must not be used. Holes must be bored for spikes in all yellow-pine planking.

DEAD OIL.

All scarfs, tenons, mortises, pile heads, siding of piles, beds for backing pieces, cross caps and side caps, and all such places where one timber crosses another must be freely treated with dead oil.

WROUGHT IRON.

All wrought iron must be fibrous in texture and have an ultimate tensile strength of not less than 40,000 pounds per square inch of cross section. Each screw bolt to have square head and nut, with a standard thread and two wrought-iron washers. The diameter of the washers will be about $3\frac{1}{2}$ times that of their bolts.

DOCK SPIKES.

Will all have spike points.

GENERAL.

The contractor will furnish all incidental material, tools, machinery, implements, scaffolding, and whatever else may be required for the construction and protection of the work. No material furnished or work done is to be considered as accepted which may be defective or deficient in any of the requirements of these specifications in consequence of any negligence of any inspector or other authorized person to point out such defect or deficiency during the execution of the work, and the contractor will be required to replace any inferior material or correct any imperfect work whenever discovered.

Any doubt as to the meaning of these specifications or any obscurity as to the wording of them will be explained, and all directions and explanations necessary or proper to make more definite and certain any of the provisions of these specifications and give them due effect will be given by the commanding officer or the officer detailed by him in charge of the work, and such directions and explanations shall be binding on the contractor the same as if they had been contained herein.

Whenever the contractor is not present orders will be received and obeyed by the overseer who may have charge of the men employed on the work.

All work done under these specifications shall be to the satisfaction of the commanding officer, and all materials and workmanship shall be subject to his inspection or rejection.

Any work shown or noted on the drawings and not especially mentioned herein, or *vice versa*, shall be executed and supplied by the contractor the same as if mentioned or shown on both, notwithstanding any errors or omissions in the one or the other, and the contractor is not to take advantage of any omissions of details in specifications or drawings, but will be required to do everything necessary to complete the work according to the intent of drawings and specifications and to the satisfaction of the commanding officer.

ESTIMATE OF QUANTITIES.

(1) Bearing piles, 73.
(2) Brace piles, 13.
(3) Spring piles, 36.
(4) Mooring piles, 5.

SIDE CAPS.

(1) 4 pieces 35 feet long,
(2) 2 pieces 37 feet long,
(3) 1 piece 39 feet long,
} 12 by 12 inches.

CROSS CAPS.

(1) 1 piece 33 feet long,
(2) 1 piece 31½ feet long,
(3) 1 piece 23 feet long,
(4) 1 piece 41 feet long,
(5) 6 pieces 34½ feet long,
(6) 4 pieces 14 feet long,
(7) 1 piece 10 feet long,
(8) 2 pieces 1½ feet long,
(9) 1 piece 26 feet long,
(10) 1 piece 30 feet long,
} 12 by 12 inches.

SIDE RANGERS.

(1) 1 piece 40½ feet long,
(2) 2 pieces 34 feet long,
(3) 1 piece 33 feet long,
(4) 1 piece 39 feet long,
(5) 1 piece 28 feet long,
(6) 1 piece 23 feet long,
} 12 by 12 inches.

INTERMEDIATE RANGERS.

(1) 1 piece 20½ feet long,
(2) 8 pieces 34 feet long,
(3) 1 piece 23 feet long,
(4) 2 pieces 10½ feet long,
(5) 2 pieces 33 feet long,
(6) 1 piece 20½ feet long,
(7) 1 piece 22½ feet long,
} 12 by 12 inches.

(1) 4 pieces 9 feet long,
(2) 16 pieces 31 feet long,
(3) 4 pieces 22 feet long,
(4) 1 piece 21 feet long,
(5) 1 piece 18½ feet long,
(6) 1 piece 15½ feet long,
(7) 1 piece 12½ feet long,
(8) 1 piece 10 feet long,
(9) 1 piece 7 feet long,
(10) 1 piece 4½ feet long,
} 6 by 12 inches.

BACKING LOGS.

(1) 1 piece 16 feet long,
(2) 2 pieces 30 feet long,
(3) 1 piece 26 feet long,
(4) 1 piece 21 feet long,
(5) 2 pieces 13 feet long,
(6) 2 pieces 20 feet long,
(7) 1 piece 18 feet long,
(8) 1 piece 32½ feet long,
(9) 1 piece 39 feet long,
} 12 by 12 inches.

SPRING PILE CHOCKS.

(1) 182 linear feet, 8 by 10 inches.
(2) 32 linear feet, 12 by 12 inches, mooring pile chocks.
(3) 30 linear feet, 12 by 12 inches, small chocks.

BRACES.

(1) 8 pairs, 39 linear feet per pair,		
(2) 1 pair, 37 linear feet per pair,		
(3) 1 pair, 30 linear feet per pair,	}	5 by 10 inches.
(4) 1 piece, 20 linear feet,		
(5) 10 pieces, 34½ linear feet each,		

DECK.

(1) 4-inch plank, 14,860 feet board measure, making a total of about 45,627 feet board measure, not counting piles.

BOLTS (TWO WASHERS TO EACH BOLT).

Diameter.	No.	Approximate length.	Remarks.	Diameter.	No.	Approximate length.	Remarks.
Ins.		*Ft. Ins.*		*Ins.*		*Ft. Ins.*	
¾	8	12 ¾	Fastening strap bolts.	1	34	1 0	Scarfs in rangers.
1	26	.....	Top of fender piles.	1	12	1 0	Scarfs in caps (all).
1	2	4 0	Securing corner piles.	⅞	22	1 0	Binding interior braces.
1	2	3 6		1	14	2 6	A-braces through brace piles.
1	2	2 6		1	8	2 0	
1⅛	13	2 6	Securing brace piles.	⅞	42	1 4	Horizontal braces.
1⅛	13	2 3		⅞	20	1 4	
1⅛	5	2 0	Securing mooring piles.				

DOCK SPIKES.

Approximate number.	Size.	Location.
	Inches.	
68	¾ by 16	Securing chocks at top of fender piles.
32	⅞ by 28	Securing backing logs.
16	⅞ by 10	Securing backing-log scarfs.
14	¾ by 16	Securing chocks at mooring piles.
34	1 by 10	Scarfs in rangers.
68	⅞ by 22	Spiking down rangers, 12 by 12 inches.
106	¾ by 20	Spiking down rangers, 6 by 12 inches.
99	⅞ by 22	Caps on piles.
10	1 by 10	Chocks between end piles.
45	¾ by 12	A-braces, to piles.
23	¾ by 12	Horizontal braces to piles.

PAINT AND OIL.

Labor and expenses of every description for removing old work and construction of new work.

The above estimate, although made as accurately as possible in advance, is approximate, and bidders must satisfy themselves by examination and any other means they may prefer. No allowance will be made on any claim based on inaccuracy in above estimate.

The successful bidder will be required to commence operations within ten days after receiving notification of the acceptance of his bid, and finish the work within fifty days thereafter.

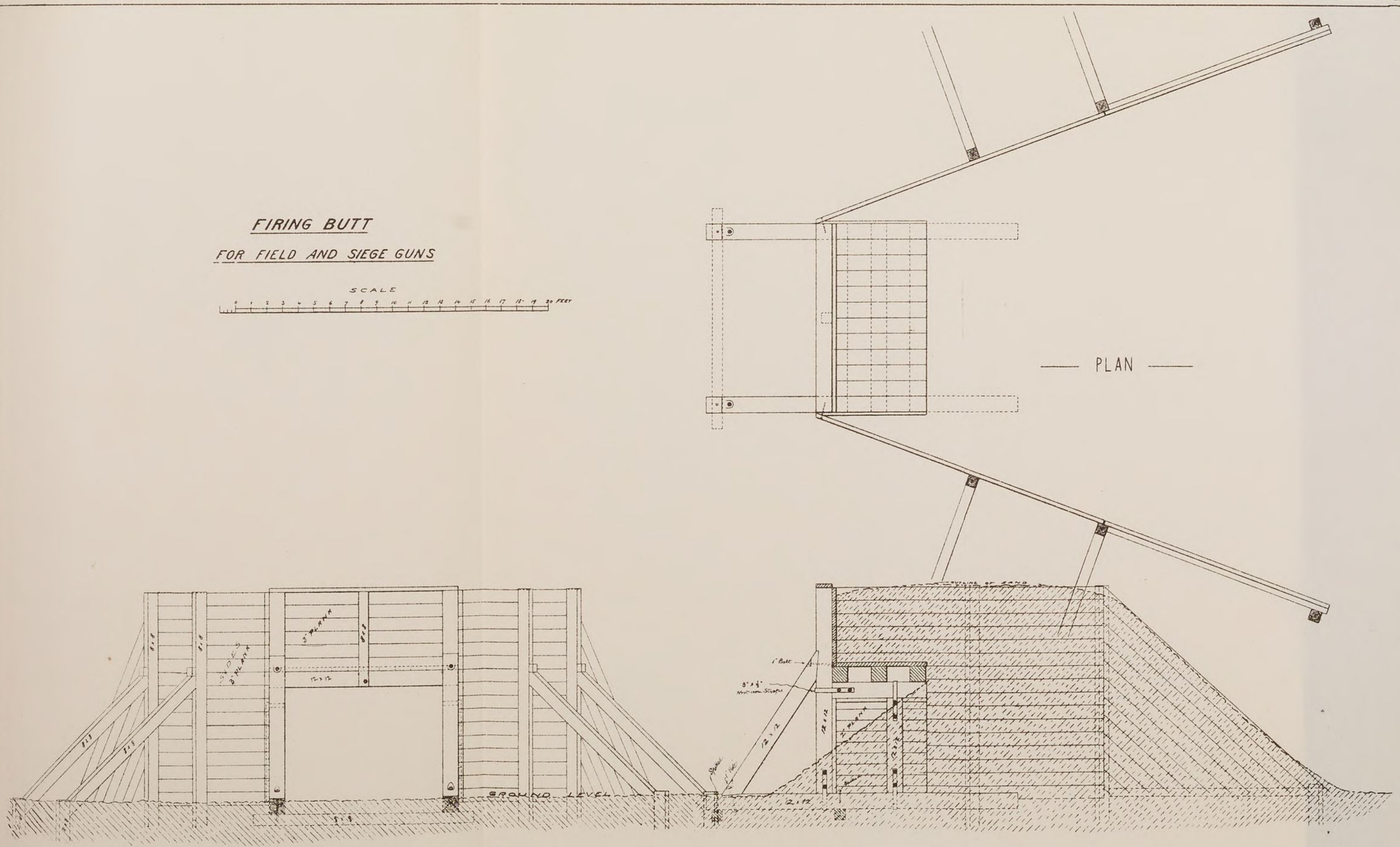
(4018–'93.)

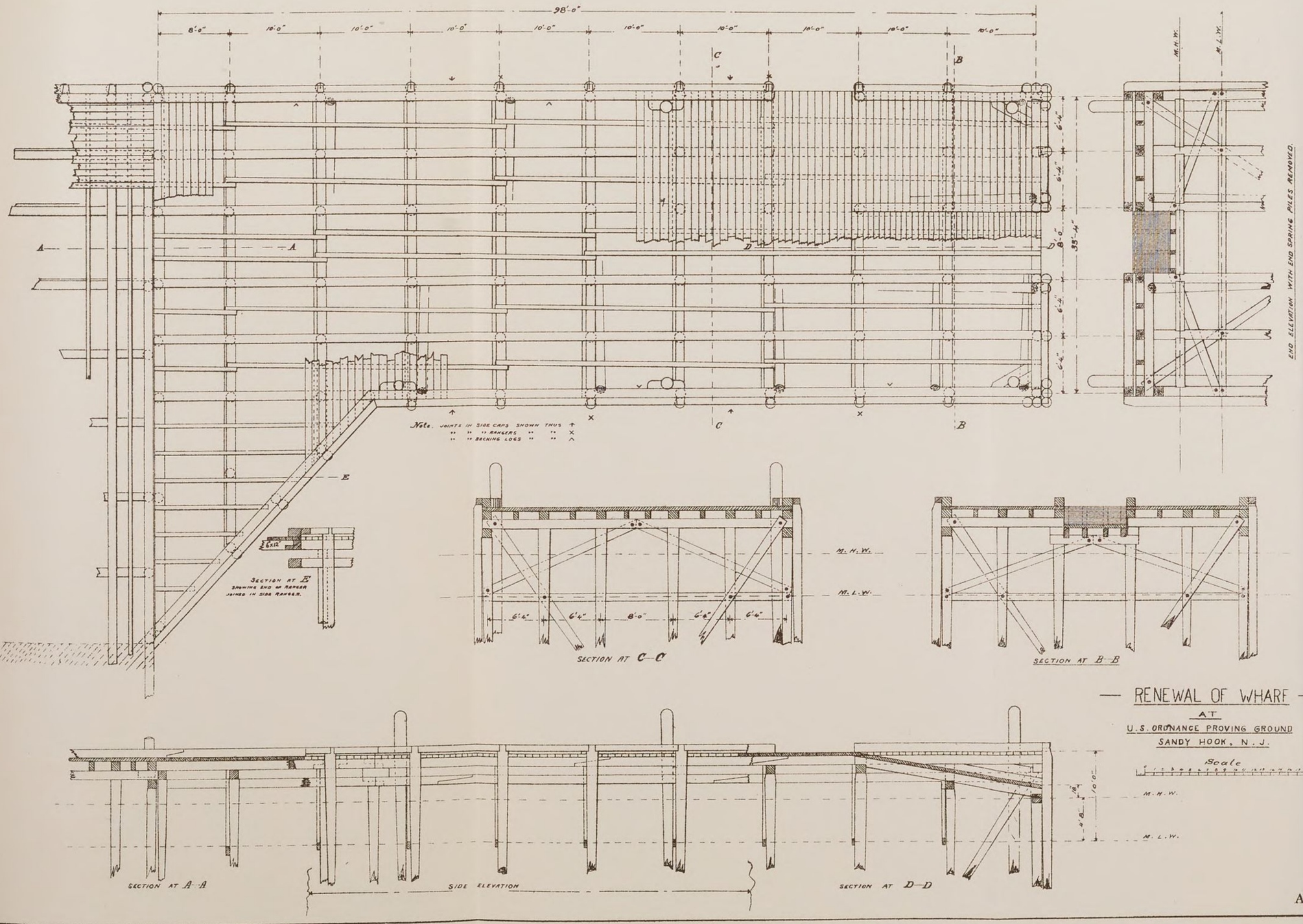
FIRING BUTT

FOR FIELD AND SIEGE GUNS

SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 FEET





— RENEWAL OF WHARF —

AT

U. S. ORDNANCE PROVING GROUND

SANDY HOOK, N. J.

Scale

FEET

APPENDIX 30.

TESTS OF SMOKELESS POWDERS.

SANDY HOOK PROVING GROUND, *August 31, 1893.*

SIR: In accordance with your instructions, I have the honor to submit herewith a summary of tests of smokeless powders made at this post up to the present date.

These tests include firings made with the following varieties of powders:

French B. N. for field guns, in the 3.2-inch field gun; French B. N. for large guns, in the 12 and 10 inch B. L. rifles; German smokeless, in the 8-inch B. L. rifle; Navy smokeless, in the 3.2-inch field and 5-inch siege guns; Cordite, in the 4.7-inch Armstrong rapid-fire gun; Troisdorf, in the 3.2-inch field, 5-inch siege, and Driggs-Schroeder 6-pounder guns; Leonard smokeless, in the 3.2-inch field and 5-inch Brown segmental wire-wound guns.

Other scattering firings have been made, but those named include all that are in any way valuable.

FRENCH B. N. (FOR FIELD GUNS).

This is made in strips 3 inches long, 0.05 inch thick, striated with lines so that it may be broken in widths as desired; texture hard and brittle; color light gray; composition not known. It has been fired in the 3.2-inch field gun (axial vent) as follows:

[Weight of gun, 829 pounds; length of bore, 26 calibers; travel of shot in bore, 22.5 calibers.]

Date.	Charge.	Muzzle velocity.	Pressure.	Remarks.
1891.	*Lbs. Ozs.*			
Aug. 10	1 2	1,439	14,100	
	2 0	1,771	22,900	
	1 14	1,694	21,100	
	1 14	1,710	21,800	
	1 14	1,679	19,905	
Oct. 21	2 3	1,878	24,000	
	2 5	1,928	27,200	
	2 7	1,992	30,400	
23	2 9	2,105	36,100	
	2 8	2,091	34,600	Made in bundles 3 inches long; ½ ounce igniter of rifle powder used with each cartridge.
27	2 8	2,051	33,200	
	2 8	2,050	33,500	
	2 8	2,076	35,000	
	2 8	2,058	33,600	
	2 8	2,068	34,100	
Nov. 6	1 14	1,661	19,000	
	1 14	1,678	19,800	
	1 14	1,676	19,900	
	1 14	1,638	18,700	
	1 14	1,680	20,400	

The powder is only partially smokeless, giving a rather dense cloud of whitish smoke, which does not dissipate quickly. No tests have been made of its keeping qualities, owing to the limited quantity received; but it does not seem to be uniform, the same charge giving variations of 40 or 41 feet in velocity.

FRENCH B. N. (FOR LARGE GUNS).

This powder is made in strips 5½ inches long, 2 inches wide, and about 1 inch thick; it has a dull yellow color and in storage a strong odor of ether; composition not known.

Eight charges have been fired in the 12-inch B. L. rifle, as follows:

[Weight of gun, 116,480 pounds; length of bore, 34 calibers; travel of shot in bore, 27.58 calibers.]

Date.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
1892.	*Lbs. Ozs.*	*Pounds.*			
July 15	170 0	1,000	1,556	17,500	First fired; not stored.
	204 0	1,000	1,846	26,400	Do.
16	221 0	999	2,010	35,700	Maximum charge that the chamber would contain.
Aug. 4	204 0	1,000	1,858	27,600	Heated 1½ hours at 100° F. and fired within 2 hours after heating.
	204 0	999	1,930	29,900	Heated 3 hours at 120° F.; next day heated one-half hour at 120° F.; built in cartridges and exposed to sun until fired.
Dec. 1	204 0	999	1,957	28,000	Stored in ordinary powder barrels since August 5, 1892.
1893.					
July 25	197 6	1,000	1,922	29,000	Stored in ordinary powder barrels since August 5, 1892; had shrunk in storage from 200 pounds.
Aug. 8	204 0	1,000	1,895	26,600	Hermetically sealed since August 5, 1892.

A 2-ounce igniter of rifle powder was used with each cartridge. At the first five rounds a considerable volume of dense, clay-colored smoke followed discharge; but these were fired from the proof carriage, where, doubtless, the appearance of the smoke is affected by the sand in front, blown up by the blast. The last three rounds were from the gun-lift battery, with a concrete parapet in front (which was still green, however, and considerably torn up by the blast from the round of December 1, 1892), so that only the last two rounds, with the clean, hard parapet, afforded good opportunity for judging of its smokelessness, and from these it was observed to be almost absolutely smokeless.

The blast from this powder is extremely severe and much greater than with brown powder.

This seems to be due to a sort of secondary explosion after discharge, as the gases are liberated from the bore, a large volume of flame issuing some 20 or 30 feet from the muzzle, the heat of which may be felt some distance in rear of the gun. The rounds of August 4, 1892, fired with charges subjected to different degrees of heat, show that both velocity and pressure are increased by it—the velocity rather more than the pressure. Stored in ordinary powder barrels for four months the velocity increased 111 feet and the pressure 1,600 pounds. In a year a charge of 200 pounds had shrunk to 197 pounds 6 ounces, still giving 76 feet more velocity and 2,600 pounds more pressure than 204 pounds had given before storage. Hermetically sealed for a year the velocity increased 49 feet, the pressure remaining about the same. It can not be said, therefore, to be a stable powder, for there seems to be no way of preserving its qualities. That it should change when stored in ordinary powder barrels is quite natural (though it would be expected to

deteriorate and not improve), but that it should change when hermetically sealed is a more serious matter. Still it should be borne in mind that all these comparisons are made from single rounds, and it is well known what variations may be expected from one round to another with large caliber guns.

Upon the whole, the results obtained with this powder in the 12-inch rifle are much more satisfactory than any yet obtained with brown powders, and indeed much better than there seems promise of obtaining with them.

Four rounds with varying charges were fired from the 10-inch B. L. rifle in June, 1892.

With all four a large column of black smoke followed discharge, and after a few seconds interval flame burst from the muzzle, accompanied by dense yellow smoke. This was evidently due to the slow combustion of a quantity of powder left in the bore, as a great deal unburned was found in front of the muzzle.

The largest charge was 120 pounds, which completely filled the chamber and gave a muzzle velocity of 1,739 feet with 22,900 pounds pressure; and the results were valuable only as showing how differently a powder may act in guns of different calibers.

GERMAN SMOKELESS.

This is in cubes 0.4 inch on a side, of very even granulation. Its exterior is coated with graphite, and within it bears much resemblance to ordinary glue; composition not known. Since July 1, 1892, there have been fired four rounds in the 8-inch B. L. rifle, as follows, some of the firings prior to this date being included also for comparison:

[Weight of gun, 32,480 pounds; length of bore, 32 calibers; travel of shot in bore, 25.66 calibers.]

Date.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
	Pounds.	*Pounds.*			
July 24, 1891	45	300	2,000	30,100	First fired; not stored.
	50	300	2,174	38,200	Do.
Nov. 4, 1891	45	300	1,985	32,900	Stored in ordinary barrels since Aug. 29, 1891.
	45	300	2,004	33,300	Hermetically sealed since Sept. 1, 1891.
Nov. 19, 1891	45	300	1,987	32,200	Do.
July 26, 1892	45	300	1,949	29,900	Stored in ordinary barrels since Aug. 29, 1891.
	45	300	1,968	30,400	Hermetically sealed since Sept. 1, 1891.
Mar. 21, 1893	45	300	1,973	30,100	Do.
Apr. 28, 1893	45	300	1,933	32,400	Stored in metallic cases, but not sealed, since Sept. 1, 1891.

A considerable cloud of smoke for so-called smokeless powder has always accompanied the discharge with this powder, but it is thought this was mainly due to sand blown up by the blast, as with B. N. powder in the 12-inch. Being stored in ordinary barrels it has gradually lost in velocity from 2,000 feet to 1,933 feet during a period of nearly two years, the pressure remaining about the same; but when hermetically sealed its qualities remained almost constant for twenty months.

In September, 1891, there were fired three rounds of 48 pounds 8 ounces to observe the effect of heat upon it. Without heating this charge gave a velocity of 2,069 feet with about 32,000 pounds pressure; two charges heated for two and three-fourths hours—one at 100 ° F. and the other at 120° F.—gave 2,099 feet and 2,106 feet, respectively, the pressure being in both cases about 28,000 pounds. But these changes are regarded as being but slight under the circumstances, for it can not be expected of any powder that its qualities will remain the

same if heated for a considerable time and then fired soon afterward. Moreover, that it loses in velocity from storage in ordinary barrels is thought to be no objection, since it has been shown conclusively that when sealed its qualities remain practically unchanged. The variations to which black and brown powders are subject from ordinary storage are too well known to urge this as any objection to a powder so superior in other respects, and should have led long before this to the universal practice of keeping powder sealed. It can be done with but little comparative expense, for which we would be many times repaid by the uniformity of the powder.

The high velocities and low pressures given by this powder show it to be much superior to any brown powder yet tested in the 8-inch rifle, and it is considered to be a highly satisfactory powder for the gun.

NAVY SMOKELESS.

This was in cylindrical rods, about 12 inches diameter and 4.4 feet long, though it would ordinarily be cut to suit the chamber of the gun. Its color is a pale yellow; it is extremely hard and brittle; composition not known, though it is believed to consist mainly of gun-cotton with a restrainer. It was fired in the 3.2-inch field and 5-inch siege guns October 17, 1892, as follows: Weight of 3.2-inch field, 829 pounds; length of bore, 26 calibers; travel of shot in bore, 22.5 calibers.

[Weight of 5-inch seige, 3,660 pounds; length of bore, 27 calibers; travel of shot in bore, 23.96 calibers.]

Gun.	Designation.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
		Pounds.	*Pounds.*			
3.2-inch field..	M. N. 2..	2	13½	1,538	17,100	Considerable powder blown out unburned at each round: ½-ounce igniter used. Three pounds completely filled the chamber of the 3.2 inch.
	.. do	2½	13½	1,862	27,900	
	M. N. 3..	3	13½	1,659	22,300	
	...do	3	13½	1,777	25,200	
	...do	3	13½	1,791	26,100	
5-inch siege...	...do	7	45	1,455	11,800	
	...do	7	45	1,497	12,100	

This powder is practically smokeless, but though giving in the 3.2 inch higher velocity and lower pressure than expected in service, it is evidently not suited to the gun, because so much was unburned, giving rise to considerable variations. Its suitability for the 5-inch can not be judged from the limited firing. It is understood that this powder has given excellent results in the Navy 6-inch.

CORDITE.

This is in flexible round rods, about 0.2 inch diameter, of very even size, cut in lengths to suit the chamber of the gun; color, dark brown; of tough gelatinous texture. Composition: nitroglycerine, 58; gun-cotton, 37; mineral jelly, 5. It has been fired several rounds in the 4.7-inch Armstrong rapid-fire gun, but the velocity has been taken with only two rounds, as follows:

[Weight of gun, 4,648 pounds; length of bore, 40 calibers; travel of shot in bore, 36.9 calibers.]

Date.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
1892.	*Pounds.*	*Pounds.*			
Sept. 29..	5½	45	2,224	30,600	Cut 14 inches long; made in bundles.
	5½	45	2,234	32,500	

It is practically smokeless, and abroad it has been exposed in an open case to all the changes of weather and climate for a year without being perceptibly affected. It has been definitely adopted for the 4.7-inch Armstrong gun and came with it for test.

On July 21, 1893, a low charge of 2 pounds was fired in this gun to test its recoil check, and it was observed that a great deal of the powder was thrown out unburned.

As the full charge is entirely consumed, it is seen that in testing a new powder the fact that all is not consumed with low charges should not lead to the conclusion that it is too slow until the limit of chamber capacity has been reached.

TROISDORF.

This came packed in blank shotgun cartridge-cases. It has the luster of plumbago, and, in bulk, a strong odor of ether. Three lots have been received—a few pounds of each, Mark II and Mark III, in October, 1892, and later a considerable quantity not designated, but which will here be called Mark IV.

The grains of Mark II were about 0.01 inch square by 0.06 inch thick; of Mark III and Mark IV about 0.1 inch square by 0.04 inch thick.

3.2-inch field gun with Gerdom breech mechanism and axial vent.

Date.	Charge.	Mark.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
1892.	*Lbs. Ozs.*		*Lbs.*			
Oct. 22	1 12	II	13½	1,935	43,400	On October 22 no igniter was used and the cartridge was loaded in the service cartridge bag, which it scarcely more than half filled, so that the cartridge was only a little over half the length of the chamber.
	1 8	II	13½	1,765	32,600	
	1 8½	II	13½	1,770	34,300	
	1 8½	II	13½	1,769	34,900	
	1 4	III	13½	1,597	25,800	
	1 8	III	13½	1,809	38,400	
	1 7	III	13½	1,763	35,600	
	1 7	III	13½	1,767	39,300	
24	1 8½	II	13½	1,757	28,000	On October 24 (and in all succeeding rounds, except when mentioned) a ½-ounce igniter was used, and the cartridge was the full length of chamber, with circumferential slack taken up, except the third round of this date, when the cartridge was full length, but the slack was not taken up.
	1 12	II	13½	1,922	31,200	
	1 12	III	13½	2,006	About 70,000	
	1 7	III	13½	1,774	28,300	
	1 12	III	13½	1,998	47,300	
Dec. 12	1 8	IV	13½	1,644	24,200	Length of cartridge: 9¾ inches.
	1 12	IV	13½	1,816	29,400	Length of cartridge: 11¼ inches.
	1 14	IV	13½	1,913	33,100	Length of cartridge: 10¾ inches.
	1 15	IV	13½	1,995	43,800	Length of cartridge: 11 inches.
	1 14	IV	13½	1,934	34,000	Length of cartridge: 10¾ inches.
	1 14¼	IV	13½	1,930	33,900	Length of cartridge: 11 inches.
	1 14¼	IV	13½	1,944	34,600	Length of cartridge: 11 inches.
	1 14¼	IV	13½	1,947	35,000	Length of cartridge, 11 inches: ½ ounce igniter.
	1 14¼	IV	13½	1,939	34,900	Length of cartridge, 11 inches: ¼ ounce igniter.
	1 14¼	IV	13½	1,931	34,800	Length of cartridge, 11 inches: ⅛ ounce igniter.
	1 9	IV	13½	1,727	Less than 32,000	
	1 8	IV	13½	1,666	(*)	
	1 8	IV	13½	1,677	24,700	Cartridge full diameter of 3.2-inch bag, 6½ inches long.
13	1 12	IV	13½	1,900	42,000	
	1 11	IV	13½	1,821	31,300	
	1 11¼	IV	13½	1,821	31,900	
	1 11½	IV	13½	1,866	34,700	
	1 11½	IV	13½	1,820	30,400	Care taken to place in rear of chamber.
	1 11½	IV	13½	1,841	34,600	Full diameter; placed from mushroom head. 7/32 inch.
	1 11½	IV	13½	1,851	38,000	Full diameter; placed from mushroom head. 7/32 inch.
	1 11½	IV	13½	1,833	32,200	Full diameter; placed from mushroom head. 1 7/32 inch.
17	1 11½	IV	13½	1,837	32,900	Full diameter; placed from mushroom head. 1 7/32 inch.
	1 11½	IV	13½	1,849	35,000	Full diameter; placed from mushroom head. 2 7/32 inches.
	1 11½	IV	13½	1,824	32,200	Full diameter; placed from mushroom head. 2 7/32 inches.
	1 11½	IV	13½	1,838	32,500	Full diameter; placed from mushroom head. 3 7/32 inches.
	1 11½	IV	13½	1,840	32,300	Full diameter; placed from mushroom head. 3 7/32 inches.
	1 11½	IV	13½	1,846	34,100	Full diameter; placed from mushroom head. 4 3/32 inches.
	1 11½	IV	13½	1,848	36,000	Full diameter; placed from mushroom head. 4 3/32 inches.

* Copper jammed.

3.2-inch field gun with Gerdom breech mechanism and axial vent—Continued.

Date.	Charge.	Mark.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
1892.	*Lbs. Ozs*		*Lbs.*			
Dec. 17	1 11½	IV	13½	1,837	31,400	Full diameter; in contact with mushroom head.
	1 8	IV	13½	1,835	30,600	
19	1 11½	IV	13½	1,825	30,300	Full diameter; cartridge placed from mushroom head. ⅛ inch.
	1 11½	IV	13½	1,847	32,400	¼ inch.
	1 11½	IV	13½	1,846	32,900	⅜ inch.
	1 11½	IV	13½	1,824	31,000	½ inch.
	1 11½	IV	13½	1,860	31,600	⅝ inch.
	1 11½	IV	13½	1,848	32,100	¾ inch.
	1 11½	IV	13½	1,855	34,200	⅞ inch.
	1 11½	IV	13½	1,848	33,800	1 inch.
	1 11½	IV	13½	1,845	32,000	1⅛ inches.
	1 11½	IV	13½	1,849	32,300	1⅜ inches.
	1 14¼	IV	13½	1,940	34,100	Cartridge full length; slack taken up.
	1 14¼	IV	13½	1,971	35,200	Cartridge full length, but suspended in center of chamber by bits of pasteboard.

3.2-inch field gun with radial vent.

1893.						
Feb. 4	1 14¼	IV	13½	1,867	29,600	In the firing with this gun the cartridge was nearly the full length of chamber; no igniter was used on account of the position of vent, and there was considerable hang fire, due to the want of it.
	1 15¼	IV	13½	1,952	32,300	
	1 15¼	IV	13½	1,948	32,400	
	1 15¼	IV	13½	1,951	32,300	
9	1 9	IV	13½	1,635	Less than 24,000	
	1 11	IV	13½	1,735	25,700	
	1 13	IV	13½	1,817	28,000	
	1 14	IV	13½	1,859	30,200	
	1 15	IV	13½	1,903	31,400	
	2 0	IV	13½	1,956	33,600	
	2 1	IV	13½	1,996	35,200	Powder fired February 18 had been heated for six hours at 120° F., and then thoroughly dried at about 100° F., for ten hours before firing.
	2 1	IV	13½	1,989	34,900	
	2 1	IV	13½	2,002	35,500	
	2 1	IV	13½	2,001	35,300	
	2 1	IV	13½	2,003	35,600	
18	2 1	IV	13½	2,016	35,000	
	2 1	IV	13½	2,006	34,800	
	2 1	IV	13½	2,015	36,800	
	2 1	IV	13½	2,032	36,100	
	2 1	IV	13½	2,014	34,700	
	2 1	IV	13½	2,042	36,400	
27	.....	.....	.....	.....	.....	Fired to observe effect of fitting rifling band to the rifling of gun.

6-pounder Driggs-Schroeder rapid-fire gun.

1893. Mar. 2	15 0	IV	6	2,104	47,100	One-half ounce igniter.

5-inch siege gun.

1893.						
Mar. 2	6 0	IV	45	1,882	28,200	One-half ounce igniter.
2	6 12	IV	45	2,071	37,500	
2	6 10	IV	45	2,049	33,200	

This powder gives a very faint clay-colored smoke, which dissipates immediately. It has not yet been tested as to its keeping qualities under different conditions of storage, being still in the original packing; but it is only slightly affected by heat, and so far as can be judged very stable and uniform. Aside from the high qualities of the powder, the above series of firings in the 3.2-inch guns are interesting in several respects. The full charge occupying only about half the capacity of the chamber, permitted considerable variations in the shape of the cartridge and its position in the chamber, and the greater part of this

firing was done to determine the most advantageous method of loading, it having been early discovered that wide variations in pressure and velocity might thus be produced.

The records of October 22 and 24 show that the pressure is very much reduced, with the same charge, when the cartridge, instead of being the full diameter of the 3.2-inch bag, is made with narrow circular cross section and about the length of the chamber. With the third round of October 24 the ordinary 3.2-inch bag was used and the powder was distributed uniformly over the length; but the circumferential slack not being taken up, it spread out over the bottom of the chamber, forming a thin flat cartridge instead of a round one, as with all the others. The reduction of 23,000 pounds in pressure between this and the last round of the same date, the only difference being in the shape of the cross section, indicates that the pressure is affected by the extent of surface of contact between the cartridge and the walls of the chamber; but it is a singular fact that the velocities were nearly the same in the two cases. With Mark IV powder the maximum charges differed by $2\frac{3}{4}$ ounces for the two methods of loading, being 1 pound $11\frac{1}{2}$ ounces for the short cartridge and 1 pound $14\frac{1}{4}$ ounces for the long one, giving about 100 feet difference in velocity.

The size of the igniter makes no difference with the action of the powder except what little might be expected from the different density of loading. With the short cartridge, a series of rounds was fired to determine the effect of placing it at different distances from the mushroom head, the distances being from the latter when closed; but as the first series did not indicate the position of maximum pressure with sufficient certainty another series was fired, changing the position by one-quarter inch near the mushroom head. Both series point out two positions of about the same maximum—one when the rear of the cartridge is seventh-eighths inch from the mushroom head, and the other when it is well forward against the projectile—the maximum being about 36,000 pounds for both positions. A minimum pressure of about 31,000 pounds is given when the cartridge is in contact with the mushroom head.

In the last round of December 19 the cartridge was raised from the bottom of the chamber and held nearly in the center by small pieces of pasteboard, for the purpose of avoiding all contact with the walls of the chamber; but the result was not instructive, since the density of loading must necessarily be increased by the material used for the purpose.

With the 3.2-inch with radial vent the maximum charge is 2 pounds 1 ounce, giving about 60 feet more velocity than 1 pound $14\frac{1}{4}$ ounces in the 3.2-inch with axial vent, the long cartridge being used in both cases.

The last round from the 3.2-inch was fired to observe the effect of fitting the rifling band to the bore.

For this purpose a shell that had been fired was recovered and the band filed down slightly so as to permit of easy entrance; it was seated slightly forward of its usual place, the corrugations of the band just entering the rifling.

On firing, the shell was thrown only a few feet from the muzzle, only a very small quantity of the charge having been consumed. It is evident, therefore, that a considerable resistance is necessary to develop the strength of this powder; a fact which, in my opinion, serves to explain, with other powders as well as with this, many of the variations in velocities and pressures that are often observed between rounds fired under conditions that are supposed to be identical; for if so much

depends upon the initial resistance as this round indicates, any inequalities in the band, even if very slight, that would affect the resistance—such as variations in dimensions, hardness of metal, or in the force with which the projectile is forced into its seat—must produce variations in the velocity and pressure.

LEONARD SMOKELESS.

This powder resembles explosive gelatine in texture and appearance, though more firm and not so clear. The exact composition is a secret, but the parties having control of it state that it contains 75 per cent nitroglycerine, some gun-cotton, an oil, and one other ingredient. It is formed in cylindrical pieces, either tubular or solid, by forcing through a die the designations $\frac{5}{8}$-inch, $\frac{7}{16}$-inch, etc., below, referring to the diameter of the die. It is then cut up into grains whose length has been for most of the samples slightly greater than the diameter.

The holes through the tubular grains vary according to the exterior diameter from about 0.07 inch to 0.15 inch diameter. Different samples have been tested as follows:

3.2-inch field gun (Gerdom).

Date.	Charge.	Projectile.	Muzzle velocity.	Pressure.		Remarks.
1893.	*Lbs. Oz.*	*Pounds.*				
Apr. 22	8	13½	1,048	9,200		Original sample, designated "U."
	14	13½	1,408	17,300		
	1 4	13½	1,730	27,400		
	1 8	13½	1,936	33,400		
	1 8	13½	2,043	52,500		Designated "J."
	1 4	13½	1,824	43,600		
	1 0	13½	1,714	23,800		Designated "N."
	1 8	13½	1,887	30,100		
	1 8	13½	1,887	28,900		
	1 8	13½	1,838	28,000		Designated tubular "N."
	1 0	13½	1,461	Less than	24,000	Designated "J."
	1 9	13½	1,853	Less than	28,000	Designated tubular "N."
	1 10½	13½	1,934	Less than	32,000	
	1 2	13½	1,525	Less than	24,000	Designated "J."
June 22	1 0	13½	1,462		15,400	Tubular "N," $\frac{7}{16}$ inch.
	1 8	13½	1,817		21,700	
	1 9	13½	1,868		23,300	
	1 10½	13½	1,944		24,300	
	1 12	13½	1,970		24,300	
	1 13½	13½	2,023		27,300	
	1 15	13½	2,086		29,600	
	2 ½	13½	2,153		30,700	
	2 2	13½	2,217		32,000	
	2 3½	13½	2,257		36,500	
	1 15	13½	2,061		29,600	Tubular "N," $\frac{7}{16}$ inch.
	2 2	13½	2,189		31,600	
23	2 3½	13½	2,245		36,600	
	2 2	13½	2,008	Less than	28,000	Tubular "N," $\frac{5}{8}$ inch.
	2 3½	13½	1,995	Less than	28,000	
	2 3½	13½	2,047		27,600	
23	2 5	13½	2,084		28,000	
	2 6½	13½	2,131	Less than	28,000	
27	2 8	13½	2,175	Less than	28,000	
	2 9½	13½	2,179		31,000	
	2 11	13½	2,201		33,400	
	2 12	13½	2,273		35,900	

3.2-inch field gun No. 18, with axial vent.

1893.					
July 13	2 12	13½	2,458	Not taken	Tubular "N," $\frac{5}{8}$-inch. The same charge that gave 35,900 pounds pressure in the 3.2-inch Gerdom.
19	1 8	13½	1,174	9,000	Solid "N," $\frac{5}{8}$-inch. Unburned grains in bore and in front of gun.
	2 0	13½	1,533	13,700	Solid "N," $\frac{5}{8}$-inch. Unburned grains in bore and in front of gun.
	2 8	13½	1,750	18,800	
20	2 0	13½	2,145	33,100	Tubular "N," $\frac{7}{16}$-inch.

5-inch Brown segmental wire-wound gun.

[Weight, 9,311 pounds; length of bore, 43.4 calibers; travel of shot in bore, 34.3 calibers.]

1893.						
June 20	6 0	62	1,576	Less than	18,000	Tubular "N," $\frac{7}{16}$ inch.
	8 0	62	1,942	About	71,000	Tubular "N," $\frac{7}{16}$ inch. The heat in the chamber was very excessive, melting away the copper gas-checks in the pressure gauges and taking off a film of metal from the gauge housings, so that the words "Frankford Arsenal" were almost completely eradicated from one of them.
21	6 0	62	1,629		18,100	Tubular "N," $\frac{5}{8}$ inch.
23	6 0	62	1,572		17,600	
July 6	6 0	62	952		9,600	Tubular "N," $1\frac{1}{2}$ inches. Much unburned.
	6 0	62	1,294	Less than	9,000	
	7 0	62	1,442		9,500	
18	7 0	63	1,637		14,800	
	8 0	63	1,719		15,600	Solid, $\frac{5}{8}$ inch.
	9 0	63	1,787		16,200	
	11 0	63	2,083		22,900	
	13 0	63	2,354		34,600	
	14 0	63	2,441		40,700	
19	11 0	63	1,573	Less than	18,000	Tubular, $1\frac{1}{2}$ inches.
	14 0	63	1,829	Less than	32,000	
	17 0	63	1,918	Less than	24,000	
Aug. 18	7 0	63	1,713		20,200	Solid, $\frac{5}{8}$ inch and length of chamber; $\frac{1}{2}$ ounce igniter at rear and 2 ounces long igniter through length of cartridge.
	7 0	63	1,712		19,100	
	9 0	63	1,865	Less than	24,000	
	11 0	63	1,991		20,900	
	13 0	63	2,225		28,700	
	15 0	63	2,397		32,800	
	17 0	63	2,521		35,100	
	*19 0	63	2,804		46,500	
	*20 0	63	2,802		46,400	
	*21 0	63	2,874		46,600	

*It was necessary to use some shorter grains in last three rounds to make cartridge full weight.

The lot tested on August 18 was said to contain impure nitroglycerine, which had been purchased in the market, and the free acid in it had turned the coloring matter intended for crimson to a deep purple. The tests so far have only been with sample lots for the information of the inventor in its development, and it is understood that, with the exception of the earliest samples, all lots have been of the same composition, the only difference being in the size and shape of the grain. It is all equally smokeless, and about the same as Troisdorf in this respect. The results obtained both in the 3.2-inch and 5-inch Brown segmental are not only remarkable in themselves and far ahead of any before obtained here, but it is believed they are the best ever obtained with any powder when the travel of the shot in the bore is considered; and the velocity of 2,874 feet is, as a matter of fact, the highest ever obtained in this country. Higher velocities have been obtained abroad, to be sure, but they were with guns in which the travel, in calibers, was much greater than in either of these. It is unfortunate that nothing can be said at present as to the stability of this powder; but it is to be hoped that it may be satisfactory in this respect, for there seems reason to expect that by suitably varying the grain it may be adapted to other guns of larger caliber.

The following table, showing the energy of the projectile per ton of gun, is made up from the best of all the foregoing results, only such rounds being included as gave pressures within the limits for which the several guns were constructed:

Date.	Gun.	Weight of gun.	Length of bore in calibers.	Travel of projectile in calibers.	Kind of powder.	Charge.	Projectile.	Muzzle velocity.	Energy per ton of gun.	Expected of the gun with black or brown powder.		Percentage over expected energy per ton of gun actually obtained.
										Muzzle velocity.	Energy per ton of gun.	
		Pounds.				*Lbs.* *Oz.*	*Pounds.*	*Ft. secs.*	*Ft. tons.*	*Ft. secs.*	*Ft. tons.*	
July 24, 1891	8-inch rifle	32,480	32.0	25.66	German	50 0	300.0	2,174	678.69	1,950	546.02	24.3
Oct. 23, 1891	3.2-inch field (axial vent)	829	26.0	22.5	French B. N	2 8	13.5	2,091	1,107.00	1,685	718.84	54.0
July 16, 1892	12-inch rifle	116,480	34.0	27.58	....do	221 0	999.0	2,010	538.73	1,975	520.64	3.5
Sept. 29, 1892	4.7-inch Armstrong	4,648	40.0	36.9	Cordite	5 5	45.0	2,234	751.19	.....	.....	.....
Feb. 18, 1893	3.2-inch field (radial vent)	829	26.0	22.5	Troisdorf	2 1	13.5	2,016	1,029.00	1,685	718.84	43.1
Mar. 2, 1893	5-inch siege	3,660	27.0	23.96	....do	6 10	45.0	2,049	802.53	1,830	640.15	25.4
June 27, 1893	3.2-inch field (Gerdom)	829	26.0	22.5	Leonard	2 12	13.5	2,273	1,308.10	1,685	718.84	82.0
Aug. 18, 1893	5-inch Brown segmental	9,311	43.4	34.3	....do	21 0	63.0	2,874	868.90	2,600	711.10	22.2

It is interesting to note in this table the great superiority of efficiency of the 3.2-inch over all the other guns with three different kinds of powder, and the excess of efficiency actually obtained in all guns over what was expected of them with black or brown powders.

For the 3.2-inch and 5-inch guns black powders have been produced which gave the muzzle velocities anticipated. For the 8 and 12 inch rifles no brown powders have yet been received that came fully up to requirements, though some lots have been very nearly satisfactory, and the representatives of the 5-inch Brown segmental gun believe that it is possible to obtain a brown powder that will meet the requirements for their gun. Granting this, it may be said, then, that the expected velocities given above are fairly estimated—certainly they are not underestimated—so that the excess of velocity over what was expected is wholly attributable to smokeless powders and their suitability to the different guns, and the figures in the last column may therefore be taken to express approximately the comparative degrees of development of smokeless powders for the respective guns.

It is but natural that such excellent results should first be obtained in the smaller guns on account of the ease and small cost with which experiments may be carried on with them for the development of powder, and it is believed that if experiments could be made as readily with the larger caliber guns much higher results than yet obtained in them would follow. It can hardly be hoped, however, that the per cent of excess as above for the 8 and 12 inch rifles will ever reach the figure of the 3.2-inch, yet this is not unreasonable and must be regarded as a possibility.

Speaking generally of these powders, they have very high ballistic properties; they are all very nearly smokeless and leave little or no residue in the bore, but we are still somewhat uncertain as to whether these qualities may be combined with uniformity and stability. There is little doubt, however, that this will be done, and that we will eventually obtain smokeless powders for all guns as much superior to black and brown powders in all respects as they have already been found to be in ballistic properties. And to this end it is recommended that more samples be procured from abroad; that all possible encouragement be extended to inventors or producers of smokeless powders in this country, and that, with such as seem promising, arrangements may be made to compensate them for the cost of producing sample lots for test and development in the larger caliber guns.

Very respectfully, your obedient servant,

FREMONT P. PECK,
Lieutenant, Ordnance Department.

The COMMANDING OFFICER SANDY HOOK PROVING GROUND.

(4907–'93.)

APPENDIX 31.

PROGRESS REPORT ON MANUFACTURE OF STEEL FORGINGS, ETC., AT THE BETHLEHEM IRON WORKS, SOUTH BETHLEHEM, PA., DURING THE FISCAL YEAR ENDED JUNE 30, 1893.

OFFICE OF INSPECTOR OF ORDNANCE, U. S. ARMY,
BETHLEHEM IRON WORKS,
South Bethlehem, Pa., August 11, 1893.

SIR: I have the honor to submit the following report of the progress during the fiscal year ended June 30, 1893, of the work ordered by the Ordnance Department to be made, under the supervision of the Inspector of Ordnance, at these works:

The Bethlehem Iron Company has continued work on the following orders, viz:

(1) Forgings for twenty-three 10-inch and fifteen 12-inch B. L. rifles, under contract of January 31, 1889.
(2) Jacket forging for 10-inch wire-wound B. L. rifle (Crozier).
(3) Twenty-four experimental steel shells for 12-inch B. L. mortars.
(4) Four steel armor plates for ballistic test of armor-piercing shot.
(5) Forged steel parts of barbette carriage for 12-inch B. L. rifle.
(6) Manufacture of twenty-five 8-inch, fifty 10-inch, and twenty-five 12-inch B. L. steel rifles.

They have also undertaken the following work under orders or contracts, viz:

(7) Forgings for seven 12-inch B. L. mortars, contract of September 26, 1892.
(8) Forgings for twelve 10-inch B. L, rifles, contract of September 26, 1892.
(9) Forgings for ten 12-inch B. L. rifles, contract of September 26, 1892.
(10) Forgings for seven 10-inch B. L. rifles, contract of June 24, 1893.
(11) Forgings for one 12-inch B. L. rifle, model 1892, nickel steel tube, contract of June 24, 1893.
(12) Forgings for seven 12-inch B. L. rifles, contract of June 24, 1893.
(13) Forgings for three bands for 8-inch Haskell multicharge gun, orders of March 6 and May 4, 1893.
(14) Miscellaneous forgings.

(1) FORGINGS FOR 10-INCH AND 12-INCH B. L. RIFLES.

The remaining ten sets of the 10-inch forgings due under the contract were delivered by February 11, 1893. Of the 12-inch forgings, eight sets were delivered, leaving five sets due to complete the contract.

(2) JACKET FORGING FOR 10-INCH WIRE-WOUND B. L. RIFLE (CROZIER).

This forging was delivered August 10, 1892. The average elastic limit was slightly below that which was required, but the metal is of a uniform good quality, and much superior to the ordinary steel casting.

(3) Twenty-four Experimental Steel Shells for 12-inch B. L. Mortars.

The fifth shell accepted under this contract was shipped April 21, 1893. The company was relieved from making further deliveries, and the contract was closed on February 4, 1893.

(4) Four Steel Armor Plates for Ballistic Test of Armor-Piercing Shot.

The replacing lot was submitted March 14, 1893, for selection of one plate to be subjected to the required ballistic test. This plate having passed successsfully, the lot was accepted and shipped.

(5) Forged Steel Parts of Barbette Carriage for 12-inch B. L. Rifle.

This contract was completed February 2, 1893.

(6) Manufacture of Twenty-five 8-inch, Fifty 10-inch, and Twenty-five 12-inch B. L. Steel Rifles.

Under this contract forgings for ten 8-inch and six 10-inch rifles have been ordered and are well advanced towards completion. Many of the hoop lathes and smaller machines are on their foundations, but none of the gun lathes and larger tools have been yet received. No work of assembling has been as yet begun, although preparations are being made for the temporary use of lathes on hand for boring and turning 8-inch tubes and jackets.

(7) Forgings for Seven 12-inch B. L. Mortars.

This contract was practically completed at the end of the fiscal year, only a few unimportant pieces remaining to be delivered.

(8, 9) Forgings for Twelve 10-inch and Ten 12-inch B. L. Rifles.

Almost all of the 10-inch have been forged and the greater part has been delivered. Of the 12-inch, about two sets have been forged, with but few deliveries.

(10, 11, 12) Forgings for Seven 10-inch and Eight 12-inch B. L. Rifles.

No work has been done under this contract.

(13) Forgings for Bands for 8-inch Haskell Multicharge Gun.

These bands were completed and submitted for test, but had not been accepted at the close of the year.

(14) Miscellaneous Forgings.

The few pieces required to replace those discovered to be defective after shipment were as follows:

8-inch spindle, delivered July 18, 1892.
3.6-inch mortar breechblock, delivered August 11, 1892.
12-inch trunnion hoop, delivered August 11, 1892.
12-inch breechblock, delivered August 11, 1892.

Ten forgings for use in the hydrostatic test of an 8-inch tube section were made for use at Watertown Arsenal, and were accepted September 23, 1892.

The following table gives the average physical qualities of specimens tested from material furnished during the year:

Designation of piece.	Number of pieces.	Average.			
		Elastic limit per square inch of original section.	Tensile strength per square inch of original section.	Elongation after rupture.	Reduction in area after rupture.
		Pounds.	*Pounds.*	*Per cent.*	*Per cent.*
8-inch tubes	3	46,090	89,000	20.6	45.8
8-inch jackets	6	49,600	91,870	21.0	47.4
8-inch trunnion hoops	5	59,200	107,520	15.7	39.1
8-inch A hoops	15	57,800	103,000	19.2	45.8
8-inch C hoops	6	58,300	102,200	18.2	40.1
8-inch D hoops	5	57,070	101,440	17.2	41.4
8-inch breech bushing	2	58,750	101,850	19.6	44.7
8-inch hinge pins	1	58,000	92,800	21.3	58.1
8-inch translating rollers	1	59,000	96,800	23.7	61.5
10-inch tubes	10	46,870	88,318	22.4	47.0
10-inch jackets	15	49,280	90,760	20.9	45.4
10-inch trunnion hoops	19	56,360	105,400	17.2	45.3
10-inch A hoops	61	60,360	105,720	16.9	45.6
10-inch B hoops	44	59,140	105,090	16.6	44.5
10-inch C hoops	62	59,400	105,430	18.2	41.9
10-inch D hoops	23	59,330	104,150	17.4	44.6
10-inch breechblocks	11	49,530	92,800	18.6	36.4
10-inch spindles	12	58,250	101,300	20.7	40.9
10-inch hinge pins	4	59,000	94,900	24.6	60.3
10-inch securing pins	2	90,500	153,600	13.6	36.1
10-inch gas-check cups	4	78,750	146,450	11.9	27.9
12-inch tubes	7	46,810	91,440	20.7	43.0
12-inch jackets	9	48,000	92,520	20.6	42.0
12-inch trunnion hoops	9	57,300	104,800	16.3	41.3
12-inch A hoops	38	58,460	103,960	17.1	46.3
12-inch B hoops	21	57,460	101,500	16.2	43.4
12-inch C hoops	48	58,600	104,330	16.7	43.3
12-inch D hoops	13	59,520	105,320	16.8	44.8
12-inch breechblocks	6	49,830	90,720	20.1	40.9
12-inch spindles	11	52,286	93,236	18.8	40.8
12-inch hinge pins	1	65,000	105,200	21.0	57.0
12-inch securing pins	3	73,667	138,000	15.4	37.6
12-inch gas-check cups	3	79,667	144,770	12.1	25.2
12-inch mortar tubes	7	47,890	88,100	21.8	47.1
12-inch mortar jackets	6	50,000	91,810	19.8	47.9
12-inch mortar trunnion hoops	7	56,000	101,300	17.1	45.4
12-inch mortar A hoops	10	58,700	103,620	17.4	46.9
12-inch mortar C hoops	15	59,920	104,170	18.5	41.7
12-inch mortar D hoops	3	60,700	106,160	17.9	46.9
12-inch mortar breech bushing	2	56,700	100,930	16.8	30.2
12-inch mortar breechblock	4	49,375	91,150	20.7	43.2
12-inch mortar spindles	4	49,750	87,600	21.6	48.5
12-inch mortar hinge pins	3	59,300	101,400	19.0	55.6
12-inch mortar translating rollers	2	58,000	100,400	18.5	52.3
12-inch mortar gas-check cups	3	87,700	155,400	16.6	29.1
Jacket for 10-inch wire-wound B. L. rifle (Crozier)	1	30,750	75,400	24.7	48.5

It will be observed from this table that the high average qualities of the material made during the previous year have been maintained through this year's work. The output has been regular, and with most

of the forgings it has been in excess of contract requirements, while there have been no delays beyond specified times of delivery.

The weights of forgings shipped during the year are as follows:

Forgings for—	Weight.
	Pounds.
10-inch B. L. rifles	1,228,683
12-inch B. L. rifles	1,149,018
12-inch B. L. mortars	291,790
Plates, bolts, nuts, and washers	63,358
10-inch wire-wound B. L. rifle jacket	23,556
Miscellaneous	30,318
Total	2,786,723

Very respectfully, your obedient servant,

I. MACNUTT,
Captain, Ord. Dept., U. S. Army, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4437–'93.)

APPENDIX 32.

PROGRESS REPORT OF MANUFACTURE OF STEEL FORGINGS, ETC., AT MIDVALE STEEL WORKS, PHILADELPHIA, PA., DURING THE FISCAL YEAR ENDED JUNE 30, 1893.

MIDVALE STEEL WORKS,
Philadelphia, Pa., September 1, 1893.

SIR: I have the honor to transmit the following report upon the operations undertaken for the Ordnance Department, U. S. Army, by the Midvale Steel Company for the fiscal year ending June 30, 1893.

All information relative to manufacture is omitted from this report upon the request of the Midvale Steel Company. The right to make this request is granted in the specifications embodied in the contracts, and all information given by the company is to be considered as confidential and for the use of the Department only:

List of fabrications.

STEEL FORGINGS.

Date of order or contract.	Date of expiration of contract or extension of contract.	No. of contract.	Fabrication.
June 15, 1891	Aug. 16, 1896	1	9 sets of steel forgings for 12-inch B. L. rifle.
Do.....	July 16, 1894	2	14 sets of steel forgings for 10-inch B. L. rifle.
Do.....	Aug. 16, 1892	3	12 sets of steel forgings for 8-inch B. L. rifle.
Sept. 19, 1892	Aug. 1, 1893	4	10 sets of steel forgings for 8-inch B. L. rifle.
June 22, 1893	Feb. 19, 1894	5	9 sets of steel forgings for 8-inch B. L. rifle.
Sept. 14, 1892	June 14, 1893	6	10 sets of steel forgings for 7-inch B. L. rifled siege howitzer.
Do.....	Dec. 14, 1892	7	1 set of steel forgings for 7-inch B. L. rifled siege mortar.
Sept. 14, 1892	June 28, 1893	8	10 sets of steel forgings for 5-inch B. L. rifled siege gun.
Do.....	Apr. 14, 1893	9	25 sets of steel forgings for 3.2 inch B. L. rifled field gun.
Dec. 13, 1890	Dec. 13, 1891	10	218 8-inch A. P. shot (extended to December 6, 1892).
Do.....	June 5, 1892	11	217 10-inch A. P. shot (extended to December 6, 1892).
June 8, 1891	Mar. 11, 1892	12	100 8-inch A. P. shot.
Do.....	Dec. 4, 1892	13	205 10-inch A. P. shot.
Do.....	Aug. 1, 1892	14	50 12-inch A. P. shot.
Oct. 15, 1892	Apr. 8, 1894	15	98 12-inch A. P. shot.
Jan. 26, 1893	Midvale own order.	16	6 12-inch mortar deck-piercing shell.
Sept. 12, 1892	Immediate...	17	1 set of steel forgings, for 10-inch disappearing carriage.

MISCELLANEOUS STEEL FORGINGS.

Sept. 12, 1892	Immediate...	18	10 forgings for 8-inch disappearing carriage for Southwark Foundry and Machine Company, viz: 1 worm shaft collar; 2 connection forgings; 1 shaft, pinion, and ratchet wheel; 1 piece 2 inches round by 34 inches long; 1 piece 1 inch square by 135 inches long; 1 piece 5 inches round by 2 inches long; 1 piece 2 inches by $1\frac{1}{4}$ inches by 36 inches long; 1 piece $2\frac{1}{8}$ inches round by 140 inches long, and 1 piece 1 inch round by 90 inches long. Total, 10 pieces.

List of fabrications—Continued.

MISCELLANEOUS STEEL FORGINGS—Continued.

Date of order or contract.	Date of expiration of contract or extension of contract.	No. of contract.	Fabrication.
Oct. 6, 1892	Oct. 29, 1892	19	74 extra forgings for Watervliet Arsenal, viz: 2 breechblocks for 3.2-inch B. L. rifle, 24 spindles for 3.2 inch B. L. rifle, 23 front gas-check cups for B. L. rifle, 23 rear gas-check cups for B. L. rifle, 1 front gas-check for 3.6-inch B. L. rifle and 1 rear gas-check for 3.6-inch B.L. rifle.
Dec. 10, 1892	Immediate...	20	3 forgings for 120-ton crane for Watervliet Arsenal, viz: 1 bale, 1 bolt, and 1 nut.
Jan. 3, 1893	....do	21	10 blanks for 5-inch projectile, Brown segmental wire-wound gun.
Jan. 4, 1893	....do	22	1 forging axle for 7-inch howitzer carriage for New York Arsenal.
Jan. 11, 1893	....do	23	1 12-inch mortar spindle, to replace spindle No. 34, condemned at Providence for defect.
Feb. 19, 1893	....do	24	1 12-inch mortar spindle, to replace spindle No. 69, condemned at Providence for defect.
Jan. 1, 1893	....do	25	7 sets of steel forgings for 8-inch barbette carriage for Watertown Arsenal, viz: 14 piston heads (steel), No. 3; 7 elevating pinions (steel), No. 3; 140 traversing rollers (steel), No. 3; 7 worms for elevating, etc.; 7 worms for elevating projectiles; 7 worms (traversing); 112 rollers; 112 roller axles; 14 piston rods (steel), No. 3; 7 piston-rod nuts, No. 3; 7 elevating racks, No. 3; 7 shafts for elevating pinion; 7 guide hooks; 28 obturating bars (steel), No. 2; 7 elevating crank shafts 80½ inches long; 7 elevating crank shafts 90½ inches long; 7 worm shafts; 7 worm shafts, elevating projectiles; 7 crank shafts, elevating projectiles; 7 shafts, elevating projectiles; 7 crank shafts (traversing); 7 journals for worm wheel; 7 frames for projectiles, 14 inches; 7 frames for projectiles, 18 inches; 7 arms for trucks; 7 transoms for trucks; 7 bolts 3 inches round by 80 inches long; 7 bolts 2 inches round by 40 inches long, and 7 bolts ¾ inch round by 60 inches long. Total, 581 pieces.
Jan. 19, 1893	....do	26	6 forgings for 8-inch disappearing carriage for Southwark Foundry and Machine Company, viz: 2 rotating arm caps and 4 bars 2 by 1¾ by 72 inches long.
Feb. 20, 1893	....do	27	6 forgings for 10-inch disappearing carriage for Southwark Foundry and Machine Company, viz: 4 bars 2 by 1¾ by 80 inches long and 2 rotating arm caps.
Feb. 21, 1893	....do	28	
Mar. 1, 1893	....do	29	4 12-inch mortar bands for Builders and Iron Foundry.
June 13, 1893	....do	31	36 12-inch mortar bands for Robt. Poole & Sons Company.
July 20, 1893	....do	32	6 12-inch mortar bands for Morgan Engineering Company.
Aug. 23, 1893	....do	33	6 12-inch mortar bands for Morgan Engineering Company.
Mar. 17, 1893	....do	34	7 extra forgings for Watervliet Arsenal, viz: 2 breechblocks for 3.6-inch B. L. rifle, 3 spindles for 3.2-inch B. L. rifle, and 2 gas-check cups for 3.2-inch B. L. rifle.
May 1, 1893	....do	35	8 forgings for 10-inch disappearing carriage for Southwark Foundry and Machine Company, viz: 1 pinion and ratchet wheel, 2 cross-head ratchet levers, 2 traversing gear cranks, 1 ratchet wheel and 2 cross-head ratchet pawls.
May 25, 1893	....do	36	1 tube for 8-inch B. L. rifle to replace tube No. 1, condemned at Watervliet Arsenal.
June 1, 1893	....do	37	4 forgings for Southwark Foundry, viz: 2 pawl stops, and 2 crank-shaft pawls.
Do.....	....do	38	6 forgings for 10-inch disappearing carriage, viz: 1 piece ¾ inch round by 10 inches long, 1 piece 1¾ inches round by 12 inches long, 1 piece 2 inches round by 12 inches long, 1 piece 2¼ inches round by 48 inches long, 1 piece 2½ inches round by 18 inches long and 1 piece 3 inches round by 6 inches long.
Do.....	....do	39	3 extra forgings for 8-inch barbette carriage for Watertown Arsenal, viz: 1 worm, 1 traversing roller, and 1 traversing crank-shaft.
June 13, 1893	....do	40	1 extra hinge pin for 8-inch B. L. rifle, to replace hinge pin spoiled at Watervliet Arsenal.
June 15, 1893	....do	41	16 valve stems for Southwark Foundry.
July 20, 1893	....do	42	21 forgings for 12-inch mortar spring-return carriage ordered by Benj. Atha & Illingworth Company, Newark, N. J., viz: 7 traversing worms and 14 hand-wheel pinions.
July 25, 1893	....do	43	12 forgings for 12-inch mortar spring-return carriage ordered by Benj. Atha & Illingworth Company, Newark, N. J., viz: 4 traversing worms and 8 hand-wheel pinions.
Aug. 17, 1893	....do	44	52 bridge pins for Rock Island Arsenal.
Aug. 23, 1893	Sept. 4, 1893	45	1 extra spindle for 10-inch B. L. rifle for Watervliet Arsenal.

List of fabrications—Continued.

STEEL CASTINGS.

Date of order or contract.	Date of expiration of contract or extension of contract.	No. of contract.	Fabrication.
June 8, 1891	To replace...	46	5 3.6-inch mortar carriages. 3 elevating arcs for same.
Aug. 3, 1892	Immediate ..	47	9 castings for 10-inch disappearing carriage.
Aug. 22, 1892	....do	48	5 castings for 10-inch disappearing carriage.
Sept. 1, 1892	....do	49	8 castings for 10-inch disappearing carriage.
Sept. 8, 1892	....do	50	7 castings for 10-inch disappearing carriage.
Oct. 11, 1892	....do	51	2 castings for 10-inch disappearing carriage.
Jan. 7, 1893	....do	52	5 8-inch barbette top carriages; 10 caps.
Mar. 30, 1893	....do	53	2 8-inch barbette top carriages; 4 caps; 14 rear-cylinder covers.
Jan. 11, 1893	....do	54	1 12-inch barbette top carriage; 2 12-inch cheeks; 1 12-inch upper roller path.
Mar. 2, 1893	....do	55	3 12-inch barbette top carriages; 6 12-inch cheeks; 3 12-inch upper roller paths.
Apr. 4, 1893	....do	56	1 3.6-inch mortar carriage, to replace one condemned at Watervliet Arsenal.
July 1, 1893	....do	57	4 3.6-inch elevating arcs, to replace condemnations.

Of the above list the following numbers have been completed: 3, 4, 6, 7, 8, 9, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, and 57. The stores represented by these numbers have been shipped to their respective destinations.

The unfinished work at the date of this report comprises Nos. 1, 2, 5, 10, 11, 12, 13, 14, 15, 16, 36, and 55. Of the unfinished work Nos. 36 and 55 are nearly completed.

No work has yet been submitted for test from Nos. 12, 13, 14, 15, and 16.

The work under Nos. 1, 2, 5, 10, and 11 is in progress at the date of this report.

References to the finished and unfinished work will be found below, under appropriate headings:

I.—12-INCH B. L. RIFLES, MODEL 1888.

(Tables I and II.)

This contract is for nine guns. The forgings for the whole of the breech mechanism have been completed, except the nine breechblocks, which are forged and awaiting machining prior to treatment. Eight of the shoulder rings are ready for shipment.

The castings for the breech plates have been made. All the castings and rough-finished forgings, except the shoulder rings, have been shipped to Watervliet Arsenal.

Preparations are in progress for the casting of the large ingots necessary for this work, and the heavy machinery for turning and boring is being installed as fast as the company can prepare the foundations and shafting.

II.—10-INCH B. L. RIFLES.

(Tables III to XIII.)

The work on the fourteen sets of forgings for these guns has been carried on this year amid an almost unexampled series of obstacles, which have delayed the execution in a way that could not have been foreseen. The number of accidents and breakages have been numer-

ous and serious. The company expect to finish the entire number by March 1, 1894.

Two complete sets of forgings have been shipped to Watervliet Arsenal, as well as all the breech mechanism, the shoulder rings, and the hoops C3 and C4 for the other twelve sets.

The following parts have been rough finished, in addition to the two sets above cited, viz: 1 tube, 1 trunnion hoop, 2 hoops A_1, 2 hoops A_2, 3 hoops A_3, 3 hoops A_4, 1 hoop B_2, 1 hoop B_3, 1 hoop C_2, 10 hoops C_3, and 1 hoop D_2.

In addition to the above, 1 tube, 2 jackets, and 2 trunnion hoops are nearly finished.

Two of the trunnion hoops were lost in machining for defects after they had been treated and tested.

III.—8-INCH B. L. RIFLES.

(*a*) Contract of June 15, 1891.

(Table XIV.)

At the date of my last report only six forgings remained unfinished, viz, 1 tube, 1 jacket, and 1 each of the A_3, A_4, and A_5 hoops. These pieces were finished November 28, 1892. The contract expired on August 16, 1892; hence the company were about three and a half months behind time.

(*b*) Contract of September 19, 1892.

(Tables XV to XIX.)

This contract was for 10 sets of steel forgings and expired on August 1, 1893. The whole number of forgings were finished May 23, 1893, or five days after the fifth set was due, thus completing the contract two and a quarter months ahead of time. No penalties were paid on this contract.

(*c*) Contract of June 22, 1893.

Nine sets of forgings are to be made under this contract. The first set will be due October 22, 1893, and then one set every fifteen days thereafter until February 19, 1894, the date of the expiration of contract. Three A_4 hoops and one breech bushing have been shipped on this order. All the spindles and gas-check cups have been forged; also 5 of the breechblocks. Some preliminary work has been done on the tubes and jackets.

IV.—SIEGE PIECES.

(Tables XX to XXX.)

The three contracts for siege pieces were all dated September 14, 1892.

(*a*) Ten sets of 7-inch B. L. Rifled Siege Howitzers.

The time allowed to make these forgings expired June 14, 1893. They were all finished on December 31, 1892. Time allowed by contract, 9 months; time required to finish forgings, $3\frac{1}{2}$ months; Midvale Steel Company ahead of time, $5\frac{1}{2}$ months.

(*b*) One set of 7-inch B. L. Rifled Siege Mortar Forgings.

This contract expired December 14, 1893, and was completed November 30, 1892, or fourteen days in advance of the expiration of contract.

(*c*) Ten sets of 5-inch B. L. Rifled Siege Guns.

This contract expired June 28, 1893, but the forgings were completed December 31, 1892, or six months in advance of date of expiration.

V.—FIELD PIECES.

(Tables XXXI to XXXIII.)

Only one contract was received during the year for these pieces. The contract, dated September 14, 1892, for twenty-five sets of forgings, comprising 3.2-inch B. L. rifled field guns, Nos. 126 to 150, both inclusive, expired April 14, 1893. The forgings were completed December 17, 1892, or three months and twenty-seven days in advance of date of expiration of contract.

VI.—ARMOR-PIERCING PROJECTILES.

The Midvale Steel Company have three contracts for these projectiles, and have placed an order of their own in the works for six 12-inch mortar deck-piercing shell. Since the receipt from France of the plans, etc., the plant has been created and the machinery installed. The work has progressed as favorably as could be expected since the completion of the preparations.

The present status of the work is given below.

(*a*) Order of January 26, 1893.

This is Midvale's own order for six 12-inch mortar deck-piercing projectiles. No work has yet been submitted, owing to the pressure of other business.

(*b*) 12-inch Armor-Piercing Projectiles.

(1) Contract of October 15, 1892: This contract is for ninety-eight 12-inch A. P. shot, and expires April 8, 1894. No work has yet been submitted, but with no unforeseen delays the shot should be delivered on time, or at latest by the end of the fiscal year ending June 30, 1894.

(2) Contract of June 8, 1891: This contract is for fifty 12-inch A. P. shot, two of which have been cast. These will follow close upon the 8-inch and 10-inch A. P. shot, and at least one lot should be completed before the end of the calendar year.

(*c*) 10-inch Armor-Piercing Projectiles.

(1) Contract of June 8, 1891: This calls for 205 10-inch A. P. shot. The ingots for these are now being cast at about the rate of 17 per week. At this date (September 1, 1893) 12 have been cast.

(2) Contract of December 13, 1890: Two hundred and seventeen are included in this contract, the ingots for all of which have been made.

Only one, so far, has been condemned. The present condition of the work on this contract is as follows, viz:

10-inch A. P. shot in cast state	16
10-inch A. P. shot in forged state	165
10-inch A. P. shot in machined state	36
10-inch A. P. shot condemned	1
Total cast	218
Total required	217

The first lot will be treated this month, and will be ready for submission to ballistic test about September 20, 1893.

(*d*) 8-INCH ARMOR-PIERCING PROJECTILES.

(1) Contract of June 8, 1891: There are 100 projectiles to be made under this contract, of which 46 have been cast. Forty-one of the latter have been accepted as to physical qualities and are ready for machining. Five are in the cast state. The whole lot of 100 will probably be completed before the end of the calendar year.

(2) Contract of December 13, 1890: There are 218 shots to be made under this contract. The present status is as follows, viz:

8-inch A. P. shot ready for ballistic test	86
8-inch A. P. shot machined	70
8-inch A. P. shot accepted as to physical qualities	62
8-inch A. P. shot condemned	6
Total cast	224
Total required	218

The first lot was submitted for ballistic test July 22, 1893, and is awaiting the action of the Department at the Sandy Hook Proving Ground. They will be tested in a few days.

The second lot of 100 will be ready for the ballistic test about September 20, 1893. The work will be prosecuted to completion at once.

VII.—MISCELLANEOUS STEEL FORGINGS.

(1) Steel forgings for 10-inch disappearing carriage: This set of forgings was completed at date of last annual report, except one rotating arm axle, which was shipped a few days later. The test was inserted in last report. (See page 565, Report of Chief of Ordnance, 1892.)

(2) Ten forgings for 8-inch disappearing carriage: (For list of these, see List of Fabrications.) All have been shipped to the Southwark Foundry, Philadelphia, Pa.

(3) Seventy-four extra forgings for Watervliet Arsenal: These comprise breechblocks and gas-check cups for 3.2-inch B. L. rifle, and 2 gas-check cups for 3.6-inch B. L. rifle. (For test, see Appendix to this report.) These forgings were turned out in three weeks from date of order. Shipped to Watervliet Arsenal November 2, 1892.

(4) Three forgings for 120-ton crane: These comprise a bolt, a bail, and a nut.

Specified qualities.		*Results of tests.*	
Tensile strength:		Tensile strength	64,000
Maximum	65,000	Elastic limit	31,000
Minimum	60,000	Elongation, per cent	36.00
Elongation, per cent, minimum	25	Contraction, do	59.11
Contraction, per cent, minimum	50		

Shipped to Watervliet Arsenal February 28, 1893.

(5) Ten blanks for 5-inch Brown projectiles: These blanks were similar to those reported last year, except they were shorter by $1\frac{1}{2}$ inches.

Specifications, minimum.		*Dimensions.*	
Tensile strength	70,000	Diameter ..... inches..	$5\frac{1}{2}$
Elastic limit	35,000	Length ..... do....	$15\frac{1}{2}$
Elongation ..... per cent..	12		
The tests gave:			
Tensile strength	75,000		
Elastic limit	44,000		
Elongation ..... per cent..	34.00		
Contraction ..... do....	61.81		

These forgings were shipped to the Diamond Drill Manufacturing Company, Birdsboro, Pa., July 22, 1893.

(6) One forging for axle for 7-inch howitzer carriage: This was what is technically known as a "rush" order. The order was received on January 4, 1893. The axle was forged, annealed, tested, and shipped to New York Arsenal on January 10, 1893. The only specifications were 90,000 tensile and 18 per cent elongation.

The test gave—

Tensile strength	88,000	Elongation ..... per cent..	27.50
Elastic limit	49,500	Contraction ..... do....	50.57

(7) Two 12-inch mortar spindles: These were extra spindles, made to replace condemnations.

The forgings gave the following results:

Marks.	Tensile strength.	Elastic limit.	Elongation.	Contraction.	To replace--
12MR77SP-T10	90,000	54,000	23.67	49.71	No. 34.
12MR80SP-T10	92,000	54,000	17.00	26.66	No. 69.
T2M	93,600	55,000	17.00	32OM	

Both of these spindles were shipped to Builders' Iron Foundry, Providence, R. I.

(8) Seven sets of forgings for 8-inch barbette carriage: There were 581 forgings in this lot. (See *supra* List of Fabrications.) The tests are given in the appendix. All were shipped to Watertown Arsenal. (Table XXXIV.)

(9) Six forgings for 8-inch disappearing carriage and six forgings for 10-inch disappearing carriage for Southwark.

Tests.	Tensile strength.	Elastic limit.	Elongation.	Contraction.	
			Per cent.	*Per cent.*	
8-inch..	88,000	53,400	28.00	50.57	Accepts 8-inch rotating-arm caps, Nos. 1 and 2.
10-inch..	90,500	56,000	28.90	50.57	Accepts 10-inch rotating-arm caps, Nos. 1 and 2.
10-inch..	76,000	45,000	35.70	64.45	Accepts 4 bars 2 by $1\frac{3}{4}$ by 80 inches for 10-inch carriage.

The four bars 2 by $1\frac{3}{4}$ by 72 inches for 8-inch carriage annealed, with the 8-inch caps above cited, were taken on tests of heat bars. All shipped to Southwark Foundry and Machine Company, Philadelphia, Pa.

(10) Mortar bands for 12-inch mortar spring-return carriage: These bands were ordered in lots as follows, viz: Fourteen sets for Builders'

Iron Foundry, Providence, R. I.; 8 sets for Builders' Iron Foundry, Providence, R. I.; 36 sets for Robt. Poole & Sons Company, Baltimore, Md.; 6 sets for Morgan Engineering Company, Alliance, Ohio; 6 sets for Morgan Engineering Company, Alliance, Ohio. The forgings were rolled and subjected to representative treatment by lots. All were promptly shipped to their several destinations. (For tests, see Appendix, Table XXXV.)

(11) Seven extra forgings for Watervliet Arsenal: These were 2 breechblocks for 3.6-inch B. L. rifle, and 3 spindles and 2 gas-check cups for 3.2-inch B. L. rifle. The tests are given in the appendix. The stores have been shipped.

(12) Eight forgings for 10-inch disappearing carriage, 4 forgings for 10-inch disappearing carriage, and 6 forgings for 10-inch disappearing carriage for Southwark. (See *supra* List of Fabrications.) The tests are respectively:

Number of forgings.	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
8	80,500	53,500	24.30	32.05
4	78,750	52,500	31.00	58.56
6	75,750	46,500	25.50	59.86

All of which were satisfactory, and the forgings were shipped to the Southwark Foundry and Machine Company, Philadelphia, Pa.

(13) One 8-inch tube (to replace tube condemned): This has been forged, but no further work has been done.

(14) Three extra forgings for 8-inch barbette carriage for Watertown Arsenal: These were 1 worm, 1 traversing roller, and 1 traversing crank shaft. The tests are as follows, viz:

Physical qualities.	Worm and traversing roller.	Traversing crank shaft.
Tensile strength	107,500	70,000
Elastic limit	52,000	45,000
Elongation	19.40	37.80
Contraction	28.16	66.56

(15) One extra hinge pin for 8-inch B. L. rifle: This pin was forged and tested with a lot for the current contract. It has been machined and will be shipped at first opportunity.

(16) Sixteen valve stems for Southwark Foundry and Machine Company: These were forged and annealed and gave the following tests:

Marks.	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
SW1VS–L1M	75,500	41,500	31.50	58.31
9VS–L1M	74,000	50,500	35.50	60.36
16VS–L1M	74,000	47,500	35.50	59.61

(17) Thirty-three forgings for 12-inch mortar spring-return carriages: These forgings were ordered by the Benj. Atha & Illingworth Company,

and consisted of 11 traversing worms and 22 hand-wheel pinions; one of the former and two of the latter forming a set.

Marks.	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
12C7TW-T2M	95,500	57,500	21.50	34.40
12C22HWP-T1M	95,000	53,000	17.00	22.71

Five sets were shipped direct to Builders' Iron Foundry, Providence, R. I.; 2 sets were shipped to Benj. Atha & Illingworth Company, Newark, N. J.; 4 sets were shipped to Robt. Poole & Sons Company, Baltimore, Md.

(18) Fifty-two bridge pins for Rock Island Arsenal: These were forged, and gave the following tests:

Marks.	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
RI1P-L1M	80,000	44,500	27.30	40.99

The pins were 4 inches in diameter, and of the following lengths: Four pins 61½ inches long, 8 pins 58½ inches long, 8 pins 50 inches long, 8 pins 47 inches long, 12 pins 45 inches long, and 12 pins 37 inches long. These were shipped to Rock Island Arsenal.

(19) One extra spindle for 10-inch B. L. rifle: This spindle was to replace one spoiled in machining.

Tests.

Marks.	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
10R15SP-T10	97,600	57,000	19.73	43.75

It has been machined and is ready to ship to Watervliet Arsenal.

VIII.—STEEL CASTINGS.

(1) 3.6-inch mortar carriages and elevating arcs: There were 6 carriages and 7 elevating arcs, made to replace condemnations. These castings have given more trouble and caused a greater number of condemnations than any order ever placed at Midvale. It is hoped that no more will require to be replaced. (Table XXXVI.)

(2) 10-inch disappearing carriage: Thirty-one castings were made for this carriage during the year. The nomenclature is contained in the tables of tests at end of this report. The castings were shipped to Southwark Foundry and Machine Company, Philadelphia, Pa. (Table XXXVII.)

(3) 8-inch barbette carriages: Seven sets of these castings were ordered and finished during the year. Each set consists of 1 top carriage, 2 caps, and 2 rear cylinder covers. All were excellent, and have been shipped to Watertown Arsenal. (For data, see Table of Tests, appended.) (Table XXXVIII.)

(4) 12-inch barbette carriage: There were two orders for these castings, one for one set and another for three sets. Each set consists of 1 top carriage, 2 "cheeks" or chassis rails, and 1 upper roller path. All have been shipped to Watertown Arsenal, except one roller path, which, barring further accidents, will be ready by end of current month. No serious trouble has been experienced with any of these castings except the roller path. This was a difficult piece to cast, on account of its section and shape. Ill fortune seemed to have settled upon this casting. Eight castings have been made to get four. The first "pulled" in shrinking during casting; the second had a clamp break in the flask after pouring; the third and fourth were good; the fifth and sixth were cracked before annealing; the seventh was good, and the eighth is now undergoing treatment. It is hoped that it will be all right. (For tests, see Table XXXIX.)

REMARKS.

The subject of steel castings has passed far beyond the experimental stage, and such castings are now an accepted fact. The progress during the past year has been greater than any preceding year. The only trouble now is in cases of complicated pattern and variable section. As much depends on the after treatment as in the selection of material. The present specifications have served their purpose and should give way to a higher standard.

Under the present specifications material must be taken which is utterly worthless as compared with what it should be.

The writer has not time now to fully discuss this subject of specifications for steel castings, but will make it the subject of a report to the Department within a short time.

The art of molding has kept pace with the appreciation in quality of material, and the surfaces that the steel molder is now able to obtain leave nothing to be desired in that particular.

Bad looking castings and inferior material are now prima-facie evidence of carelessness and ignorance. The difference between good and bad material is but a fraction of a cent per pound, and the Government should insist on having good material, since it will cost no more.

IX.—OUTSIDE WORK.

In addition to my duties here, a great deal of time has been spent on inspection duty, etc., at other works, notably at Newark, N. J., Birdsboro, Pa., Pencoyd, Pa., Chester, Pa., and Southwark Foundry and Machine Company, Philadelphia, Pa.

The Benj. Atha & Illingworth Company, of Newark, N. J., are the subcontractors to furnish 71 sets of steel castings and steel forgings for 12-inch mortar spring-return carriages, to be distributed as follows: Twenty-two sets to Builders' Iron Foundry, Providence, R. I.; 36 sets to Robt. Poole & Sons Company, Baltimore, Md.; 6 sets to Morgan Engineering Company, Alliance, Ohio, and 7 sets to West Point Foundry, Cold Spring, N. Y. The latter are for the 12-inch steel mortars. The work at Newark, N. J., will be shown in a separate report.

The work at Southwark Foundry consisted in making bronze castings for 8 and 10 inch disappearing carriages.

The tests are given in the appendix, and call for no special notice.

The work at Chester consists of bronze castings made by the Crown Smelting Company for 8 and 10 inch disappearing carriages made by Southwark Foundry, and for 12-inch mortar carriage made by Morgan Engineering Company. The Crown Smelting Company have been very successful in making satisfactory castings.

The Penn Steel Casting Company, of Chester, Pa., have some steel castings for Watertown Arsenal. Nothing has yet been done towards the inspection of this material.

The material furnished by the Pencoyd Iron Works, Pencoyd, Pa., was ordered for use in the 12-inch mortar spring-return carriages by the Morgan Engineering Company, and by Robt. Poole & Sons Company.

Nothing but wrought iron was procured from Pencoyd Iron Works.

The tests are given in the tables appended to progress report for Benj. Atha & Illingworth Company.

BIRDSBORO, PA.

The Pennsylvania Diamond Drill and Manufacturing Company, of Birdsboro, Pa., had the contract for furnishing 100 5-inch projectiles for the 5-inch Brown segmental wire-wound gun. These are forged, steel-cored, ogival shot.

The blanks or cylinders were furnished by the Midvale Steel Company, and were included in my annual report of operations at Midvale Steel Works for 1892. The shot were fabricated by the Pennsylvania Diamond Drill and Manufacturing Company, of Birdsboro, Pa., for the trustees of the Brown segmental wire-wound gun. The contract was dated September 25, 1891, expired December 31, 1892, and was extended by the Chief of Ordnance, U. S. Army, to April 1, 1893. The original specifications anticipated casting the shot, but were afterwards modified to require forged steel. The specifications as modified were as follows:

That the said projectiles shall be turned and bored from annealed bars of open-hearth steel, each bar to be of sufficient length for ten projectiles. The bars are to be tested by taking one longitudinal test specimen from each bar, 2 inches in length between shoulders and 0.505 inches in diameter. These specimens must show the physical qualities prescribed below.

The projectiles must be sound and of good finish, generally free from cracks, flaws, cavities, or other defects, and may be subjected to a steam pressure, if deemed desirable, of 50 pounds per square inch. All projectiles to be inspected by the officer of the Government before reception.

Principal dimensions, weight, etc.

	Prescribed dimensions.	Variations.	Allowed.
		Plus.	*Minus.*
Total length.....inches..	15.00	0.05	0.05
Diameter of swell.....do....	4.97	.01	.01
Diameter of cylinder.....do....	4.95	.02	.02
Exterior diameter of band.....do....	5.12	.01	.00
Diameter at bottom of band score.....do....	4.65	.02	.02
Width at top of band score.....do....	1.15	.01	.01
Width at bottom of band score.....do....	1.20	.01	.01
Weight.....pounds..	60	2	2

Physical qualities.—Tensile strength not less than 70,000 pounds per square inch; elastic limit, 35,000 pounds per square inch; elongation in 2-inch specimens not less than 12 per cent.

Subject of measurement.	Prescribed dimensions.	Allowed variations.
Length of cylindrical portion of body to shoulder	8.38 inches	+1½ per cent.
Length of cylindrical band of body (swell)	1 inch	+1½ per cent.
Length of head	6.62 inches	—2 per cent.
Length in rear of band	1.50 inches	±0.05 inch.
Total length of projectile (3 calibers)	15 inches	±0.05 inch.
Radius of head	10 inches	±0.05 inch.
Diameter of cylindrical portion to shoulder	4.95 inches	±0.02 inch.
Diameter of cylindrical band (swell)	4.97 inches	±0.01 inch.
Diameter under band	4.65 inches	±0.01 inch.
Number of grooves	1	
Depth of groove	0.15 inch	±0.02 inch.
Width of groove:		
Top	1.15 inches	±0.01 inch.
Bottom	1.20 inches	±0.01 inch.
Maximum diameter of cavity	2 inches	±0.20 inch.
Length of interior cavity	6.40 inches	±0.20 inch.
Thickness of walls at 3.4 inches from bore	1.475 inches	
Diameter of screw plug hole:		
Top of thread	2 inches	±0.01 inch.
Base of thread	2.20 inches	±0.01 inch.
Length and pitch of thread-screw plug hole	1.90 inches	
Exterior diameter of band	5.12 inches	±0.01 inch.
Interior diameter of band	4.65 inches	±0.02 inch.
Thickness (maximum) of outer lip (for base around plug)	0.30 inch	±0.01 inch. ±0.02 inch.
Weight of projectile complete	60 pounds	±2 pounds.
Number of 5-inch steel-cored shot examined	100	
Total number accepted	100	
Weight of total number accepted, about	5,900 pounds	
Mean weight of projectile, about	61 pounds	
Weight of complete projectiles accepted:*		
Heaviest	61½ pounds	
Lightest	60½ pounds	
Average	61 pounds, scant.	
Number of bands examined	100	
Number of bands accepted	100	
Weight of total number accepted, about	200 pounds	
Mean weight of band	2 pounds	
Weight of total number of complete projectiles accepted, about	6,100 pounds	
Mean weight of projectiles, about	61 pounds	

* All the projectiles except three were weighed before banding, and all weighed 59 pounds, with a variation of less than ± one-half pound. One weighed after band finished gave 60½ pounds; one with band unfinished gave 61½ pounds.

Physical properties.

	Elastic limit.	Tensile strength.
Mean prescribed, not less than	35,000	70,000
Actual:		
Maximum	48,000	88,000
Minimum	40,000	75,000
Mean	77,250	83,304
Composition of band metal		Copper, cast.

X—RÉSUMÉ.

To give a condensed statement of the physical properties of the gun forgings, tables A, B, C, D, and E, given below, have been prepared.

In these tables the columns headed "Mean" are the arithmetical means of all specimens tested.

The columns headed "Maximum" and "Minimum" give the highest and lowest results in each particular, taken separately, found in the whole series of bars tested.

The object of these two headings is to show the extreme range in each particular, viz: Tensile strength, elastic limit, elongation, and contraction of area.

Though some of the specimens show abnormal results, due to defects in the bar, which were known to the inspector before testing, all such have been included in getting the arithmetical means and reduce the results somewhat.

Recapitulation of maximum, mean, and minimum of tensile tests.

TABLE A.—PARTS OF 10-INCH B. L. RIFLE.

Name of piece.	Tested.		Maximum.				Mean.				Minimum.			
	Number of pieces.	Number of bars.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	2	13	46,000	88,000	25.50	53.64	44,161	82,845	19.27	38.50	42,000	79,600	10.00	25.13
Jackets	2	13	51,000	106,800	22.70	50.70	45,923	90,231	18.31	35.48	40,000	83,400	15.00	25.43
Trunnion hoops	5	14	59,000	104,400	21.50	56.03	55,286	106,072	19.01	43.97	51,000	94,400	14.80	22.65
Hoops A_1	2	6	65,000	112,000	16.70	40.25	55,167	101,733	14.36	27.13	51,000	93,200	12.30	16.94
A_2	3	9	59,000	103,600	19.30	46.12	54,333	99,412	16.50	40.48	52,000	93,200	14.20	34.92
A_3	4	12	62,000	108,800	18.73	46.38	57,666	103,700	16.38	37.61	53,000	94,800	13.20	26.66
A_4	1	3	59,000	105,600	16.30	39.14	56,000	101,066	15.17	32.82	54,000	97,600	13.20	28.17
A_5	2	6	56,000	102,400	16.65	51.94	53,000	97,693	17.16	40.10	51,000	92,800	14.90	31.14
B_2	1	3	53,000	95,200	20.50	38.30	53,000	94,266	18.75	37.56	53,000	93,600	17.00	37.19
B_3	2	6	56,000	107,600	17.30	40.52	54,833	106,733	15.19	32.48	54,000	98,800	13.20	26.05
B_4	2	6	57,000	100,000	18.30	46.38	54,500	97,800	15.55	33.00	53,000	94,000	11.90	15.32
C_1	2	7	56,000	104,400	17.40	32.32	53,143	99,771	15.39	25.77	52,000	94,000	12.00	17.29
C_2	2	6	57,000	101,600	18.00	36.91	54,833	99,933	16.51	29.50	53,000	98,000	15.40	22.34
C_3	15	45	64,000	108,000	23.00	50.96	56,733	101,020	18.53	33.33	51,000	94,000	14.30	17.91
C_4	14	42	64,000	106,800	23.20	55.33	56,095	94,626	18.92	41.09	51,000	94,800	14.26	24.82
C_5	12	36	65,000	113,600	23.10	52.65	57,722	102,054	18.16	40.14	52,000	92,000	14.10	22.04
D_1	2	6	57,000	107,600	17.00	34.92	54,333	102,000	14.95	27.35	52,000	96,400	13.52	23.27
D_2	1	3	55,000	101,200	22.33	40.79	54,333	98,533	17.39	31.80	53,000	96,800	14.00	18.55
Breechblocks	7	7	53,000	96,000	22.50	46.38	50,857	93,714	20.16	41.20	47,000	92,000	17.00	36.63
Gas checks	7	14	89,000	152,640	17.40	40.25	83,429	144,726	12.51	28.18	73,000	129,600	9.13	11.70
Spindles	7	7	56,000	98,000	21.10	51.70	54,429	95,784	17.40	33.39	53,000	92,800	8.80	11.70
Rotating rings	1	3	60,000	100,800	25.30	57.56	58,333	97,033	19.61	47.07	57,000	93,500	16.53	38.30
Securing pins	7	7	96,000	156,000	19.50	47.52	88,429	146,500	16.51	38.27	80,000	131,000	15.40	35.05
Hinge pins	4	4	55,000	90,000	24.70	63.01	52,250	88,600	23.05	60.46	49,000	87,600	19.20	57.65

TABLE B.—PARTS OF 8-INCH B. L. RIFLE.

Tubes	11	66	51,000	91,240	28.00	52.65	46,455	83,189	20.01	35.42	41,000	78,000	15.20	15.00
Jackets	11	69	57,000	105,600	24.50	49.20	49,245	88,664	19.64	36.75	40,000	82,800	10.00	18.87
Trunnion hoops	11	33	77,000	104,000	23.10	56.50	55,273	94,801	19.70	47.92	50,000	92,000	16.70	28.77
Hoops A_1	8	23	60,000	106,000	21.50	50.96	53,609	98,526	17.38	32.16	50,000	93,600	15.10	22.65
A_3	7	21	60,000	110,400	23.10	41.61	54,809	100,781	16.52	31.32	50,000	94,000	14.00	21.41
A_4	7	22	60,000	104,000	21.33	45.34	56,762	98,018	17.25	35.94	50,000	94,920	14.00	25.13
A_5	6	18	60,000	107,360	19.30	39.19	55,277	99,424	16.32	30.02	53,000	91,600	14.30	24.20
C_1	10	30	61,000	106,000	21.30	46.12	55,133	98,544	17.75	34.33	52,000	92,400	8.30	11.03

C_2	10	30	60,000	102,800	22.30	49.46	53,666	97,431	17.92	36.63	52,000	92,400	15.00	28.17
C_3	10	30	61,000	109,200	20.40	48.18	55,000	100,113	17.26	33.11	51,000	94,800	15.00	24.51
C_4	10	30	57,000	103,600	21.53	41.87	53,333	97,446	17.74	32.63	51,000	92,000	15.00	16.30
C_5	10	30	58,000	107,600	22.20	41.34	53,666	99,149	16.91	31.02	51,000	94,000	12.50	15.97
D_1	7	21	58,000	100,800	21.50	46.64	53,619	96,038	18.08	35.82	50,000	92,400	15.10	25.13
D_2	5	15	59,000	106,800	20.00	47.40	54,000	99,733	16.49	32.94	50,000	92,800	14.30	22.04
Breech bushing	4	8	61,000	108,000	22.00	39.44	56,375	103,306	19.98	35.65	52,000	97,500	19.50	29.85
Breechblocks	5	5	49,000	91,200	22.80	49.46	48,600	89,040	19.86	37.71	48,000	87,600	26.96	16.10
Gas checks	5	11	78,000	128,400	19.30	45.34	74,455	126,254	16.14	42.12	70,000	118,000	14.30	38.58
Spindles	6	6	52,000	90,500	26.20	54.41	50,333	89,708	23.18	44.46	48,000	89,000	19.50	32.45
Rotating rings	2	2	53,000	96,400	22.20	51.94	53,000	95,600	22.05	50.32	53,000	94,800	21.90	48.70
Securing pins	2	2	79,000	128,000	17.70	47.40	78,500	127,900	17.60	47.14	78,000	127,800	17.50	46.89
Hinge pins	2	2	55,000	91,200	24.20	63.01	52,000	87,850	24.10	61.56	49,000	84,500	24.00	60.11

TABLE C.—PARTS OF 7-INCH B. L. RIFLED HOWITZER.

Tubes	10	41	50,000	90,000	30.00	54.60	46,341	81,844	24.11	39.97	41,000	73,800	17.50	28.16
Jackets	10	40	57,000	103,200	24.40	50.46	51,150	93,848	20.22	39.69	47,000	86,400	17.00	26.96
Trunnion hoops	10	21	60,000	102,800	25.00	55.32	55,766	97,143	21.39	45.67	50,000	90,000	18.50	37.19
Sleeves	10	20	61,000	111,000	27.50	53.62	58,000	99,508	22.09	42.51	51,000	90,000	18.70	29.15
Breechblocks	4	4	60,000	98,500	23.80	46.03	53,250	94,750	21.57	41.55	48,000	90,500	20.00	38.49
Gas checks	4	4	81,000	131,000	19.50	46.03	78,750	129,500	18.02	42.40	77,000	127,500	16.50	40.99
Spindles	4	4	63,000	102,000	27.10	61.81	60,500	99,687	26.95	59.63	59,000	98,000	26.70	56.76
Base rings	6	6	59,000	100,500	23.90	50.02	56,333	99,000	22.29	43.36	55,000	97,000	18.50	34.09
Block carriers	2	2	57,000	96,000	25.30	49.47	55,500	94,500	24.15	47.17	54,000	93,000	23.00	44.88
Face plates	2	2	55,000	95,250	22.20	45.43	53,000	94,125	21.30	44.71	51,000	93,000	20.40	43.98
Lever handles	2	2	59,000	99,000	26.70	61.36	58,000	98,250	26.55	61.11	57,000	97,500	26.40	60.86
Key rings	2	2	53,000	93,000	28.00	50.57	52,500	93,000	26.30	48.73	52,000	93,000	24.60	46.88

TABLE D.—PARTS OF 5-INCH B. L. RIFLED SIEGE GUNS.

Tubes	10	42	55,000	93,500	29.00	57.00	46,833	84,820	22.11	38.98	40,000	78,950	16.00	30.85
Jackets	10	41	60,000	96,800	24.20	51.70	50,220	89,320	19.43	38.04	46,000	86,400	16.00	21.40
Trunnion hoops	10	20	59,000	99,600	26.20	57.88	54,850	95,770	20.57	51.38	50,000	94,000	19.20	45.60
Sleeves	10	20	63,000	107,500	25.00	45.73	55,450	99,455	20.87	38.52	53,000	91,500	16.20	20.97
Breechblocks	4	4	53,000	94,000	21.80	41.89	51,500	92,688	21.08	38.24	50,000	91,000	21.80	34.09
Gas checks	4	4	83,000	135,000	20.00	42.48	80,250	130,500	18.15	41.42	79,000	127,000	16.60	40.34
Spindles	4	4	63,000	96,000	29.50	64.25	57,500	95,325	27.52	60.58	54,000	95,000	26.00	56.01
Base rings	6	6	60,000	102,000	24.00	48.92	55,333	99,666	21.78	42.99	53,000	97,000	20.50	38.84
Block carriers	2	2	49,000	90,000	23.00	42.78	49,000	89,500	22.00	38.59	49,000	89,000	21.00	34.40
Lever handles	2	2	56,000	91,000	30.00	64.45	55,500	90,625	29.70	64.10	55,000	90,250	29.40	63.75
Key rings	4	4	53,000	92,250	28.20	60.11	51,500	90,875	26.32	52.02	51,000	90,000	24.00	41.89

Recapitulation of maximum, mean, and minimum of tensile tests—Continued.

TABLE E.—PARTS OF 3.2-INCH B. L. RIFLE.

Name of piece.	Tested.		Maximum.				Mean.				Minimum.			
	Number of pieces.	Number of bars.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	25	100	53,000	90,000	36.00	61.50	46,496	82,818	25.35	45.05	40,000	79,000	20.00	32.80
Jackets	26	106	58,000	99,500	29.50	51.12	48,905	90,978	23.37	41.22	45,000	84,900	11.40	15.57
Breechblocks	6	6	51,000	94,500	26.00	46.33	49,166	90,733	23.21	42.42	48,000	89,750	21.60	35.70
Gas checks	10	10	84,000	132,500	19.00	45.73	80,300	128,950	16.66	37.93	77,000	127,000	12.50	29.85
Spindles	10	10	64,000	102,000	33.50	64.70	55,700	93,900	28.09	59.26	46,000	85,000	23.00	51.12
Block carriers	3	3	58,000	101,000	22.70	42.48	56,000	98,833	21.80	40.55	53,000	95,500	20.20	39.44
Lever handles	3	3	62,000	99,500	27.30	58.86	60,000	98,333	26.23	58.16	57,000	96,500	24.60	57.31

Weights of forgings.

Designation.	Number of sets required.	Aggregate weight.
		Pounds.
12-inch B. L. rifle (contract of June 15, 1891; breech mechanism)	9	19,201
10-inch B. L. rifle (contract of June 15, 1891)	14	279,024
8-inch B. L. rifle (contract of September 19, 1892; completed)	10	398,187
8-inch B. L. rifle (contract of June 15, 1891; six pieces; completed)	12	28,457
8-inch B. L. rifle (contract of June 22, 1893; four pieces)	9	3,302
7-inch B. L. rifled siege howitzer (contract of September 14, 1892; completed)	10	57,197
7-inch B. L. rifled siege mortar (contract of September 14, 1892; completed)	1	2,239
5-inch B. L. rifled siege guns (contract of September 14, 1892; completed)	10	55,590
3.2-inch B. L. rifled field guns (contract of September 14, 1892; completed)	25	32,404
Forgings for 8-inch barbette carriage (completed)	7	63,951
12-inch mortar bands (immediate orders)	.....	14,126
Brown projectile blanks	.....	10,000
Miscellaneous forgings	.....	11,004
Total	.....	974,682

Weights of steel castings.

Designation.	Aggregate weight.
	Pounds.
Castings for 12-inch barbette carriages	220,333
Castings for 10-inch disappearing carriages	91,564
Castings for 8-inch barbette carriages	51,329
Miscellaneous castings	1,698
Total	364,924

Number of pieces shipped.

12-inch B. L. rifle	90	8 and 10 inch A. P. shot	10
10-inch B. L. rifle	237	Miscellaneous forgings	893
8-inch B. L. rifle	261	Miscellaneous steel castings	95
7-inch B. L. rifled siege howitzer	130		
7-inch B. L. rifled mortar	5	Total	2,076
5-inch B. L. rifle	130	Total number of specimens tested	1,735
3.2-inch B. L. rifle	225		

The above are from the Midvale Steel Works alone, omitting all pieces shipped from other points, which were tested and inspected by inspector at Midvale Steel Works.

Respectfully submitted.

D. A. LYLE,
Captain, Ord. Dept., U. S. Army, Inspector.

CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(5334–'93.)

ANNUAL PROGRESS REPORT OF THE INSPECTOR OF ORDNANCE, U. S. ARMY, AT THE BENJ. ATHA & ILLINGWORTH COMPANY'S WORKS, NEWARK, N. J., 1893.

PHILADELPHIA, PA., *September 30, 1893.*

SIR: I have the honor to submit the following progress report upon the manufacture of steel forgings and steel castings made by the Benj. Atha & Illingworth Company, Newark, N. J., for 12-inch mortar spring-return carriages. This company is the subcontractor for furnishing the material for the builders of the carriages. The Benj.

Atha & Illingworth Company has received the following orders for material (forgings and castings), viz:

	Sets.
From Builders' Iron Foundry, Providence, R. I., for	22
From Robt. Poole & Son Company, Baltimore, Md., for	36
From Morgan Engineering Company, Alliance, Ohio, for	6
From West Point Foundry, Cold Spring, N. Y., for	7
Total	71

STEEL FORGINGS.

(1) Twenty-two sets ordered by Builders' Iron Foundry, Providence, R. I.

Designation.	Class of steel.	Number of pieces.	Designation.	Class of steel.	Number of pieces.
Rollers	3	528	Spring compression screws	2	44
Piston-rods	3	44	Training-worm shafts	2	22
Elevating rack pinions	2	44	Hand-wheel shafts	2	44
Traversing worms	2	22	Vertical training shafts	2	22
Elevating hand-wheel pinions	2	44	Loading screws	2	22
Loading mechanism shafts	2	22			
Scoop studs	2	22	Total		880

(2) Thirty-six sets ordered by Robt. Poole & Son Company, Baltimore, Md.

Designation.	Class of steel.	Number of pieces.	Designation.	Class of steel.	Number of pieces.
Rollers	3	864	Washer for pinion	2	1
Piston-rods	3	74	Vertical training shaft	2	38
Elevating rack pinions	2	76	Worm shaft	2	38
Training worms	2	14	Screw shaft	2	38
Pinion for hand wheel	2	38	Rack shaft for loading mechanism	2	7
Key for piston-rods (flat)	2	7	Taper pin for rack shaft	2	4
Key for elevating rack pinions	2	20	2¼-inch round stud for lever	2	7
Spring compression screws	2	13	1¾-inch spring compression bolt	2	40
Shafts for elevating hand wheel	2	22			
Washer for elevating hand wheel	2	1	Total		1,302

(3) Six sets ordered by Morgan Engineering Company, Alliance, Ohio.

Designation.	Class of steel.	Number of pieces.	Designation.	Class of steel.	Number of pieces.
Rollers	3	144	1⅜-inch round	2	12
Piston-rods	3	12	2-inch round	2	6
Elevating rack pinion shafts	2	12	2¼-inch round	2	6
Traversing worms	2	6	3¼-inch round	2	12
Elevating hand-wheel pinions	2	12	3½-inch round	2	6
Vertical training shafts	2	6			
Loading screws	2	6	Total		240

(4) Seven sets ordered by West Point Foundry Company, Cold Spring, N. Y.

Designation.	Class of steel.	Number of pieces.	Designation.	Class of steel.	Number of pieces.
Rollers	3	168	Hand-wheel shafts	2	14
Piston rods	3	14	Loading screws	2	7
Elevating rack pinions	2	14	Spring compression bolts	2	7
Vertical training shaft	2	7	Training worms	2	7
Loading mechanism shaft	2	7	Hand-wheel pinions	2	14
Scoop studs	2	7			
Spring compression screws	2	14	Total		287
Training worm shafts	2	7			

STEEL CASTINGS.

As the steel castings were practically the same as far as pattern and number were concerned for each of the orders, they have been consolidated in the following summary, viz:

Designation.	Class of steel.	Total sets.	Total number of pieces.
Hydraulic cylinders	2	71	142
Trunnion carriages	1	71	142
Brackets	1	71	142
Flanges	1	71	71
Total	.....	71	497

General summary of orders.

Steel forgings:	
Builders' Iron Foundry, Providence, R. I	880
Robt. Poole & Son Company, Baltimore, Md	1,302
Morgan Engineering Company, Alliance, Ohio	240
West Point Foundry, Cold Spring, N. Y	287
Total steel forgings	2,709
Steel castings	497
Grand total	3,206

PRESENT STATUS OF WORK.

Steel forgings.

Total number of forgings required	2,709
Total number of miscellaneous forgings shipped	1,105
Total number of traversing rollers required	1,604

All the miscellaneous forgings have been fabricated, tested, and shipped, as have also 41 sets, or 984 rollers. The details of the roller shipments are given in the following summary:

Shipments of traversing rollers.

To whom shipped.	Number of sets.			Number of rollers.		
	Required.	Shipped.	Still due.	Required.	Shipped.	Still due.
Builders' Iron Foundry	22	19	3	528	456	72
Robt. Poole & Son Company	36	13	23	864	312	552
Morgan Engineering Company	6	6	.....	144	144	.....
West Point Foundry	7	3	4	168	72	96
Total	71	41	30	1,704	984	720

In dealing with the steel forgings the work was carefully laid out in advance, and representative treatment adopted wherever possible to diminish labor and cost of testing.

Like all new work the company had considerable difficulty at first in filling the requirements of the specifications, owing to lack of proper facilities in the way of plant and experience with such work.

The only forgings remaining unfinished at these works are 30 sets, or 720 traversing rollers, of which 8 sets are nearly ready for shipment.

Steel castings.

Hydraulic cylinders:			
Total cast			125
Total shipped		54	
Total accepted		15	
Total submitted		9	
			78
Total rejected or in cast state			47
Trunnion carriages:			
Total cast			130
Total shipped		71	
Total accepted		18	
			89
Total rejected or in cast state			41
Brackets:			
Total cast			101
Total shipped		54	
Total accepted		24	
			78
Total rejected or in cast state			23
Flanges:			
Total cast			76
Total shipped		18	
Total accepted		54	
			72
Total rejected or in cast state			4

Details of shipment.

	Number required.	Number shipped.	Still due.
Hydraulic cylinders:			
Builders' Iron Foundry	44	29	15
Robt. Poole & Son Company	72	19	53
Morgan Engineering Company	12	6	6
West Point Foundry Company	14	.....	14
Total	142	54	88
Trunnion carriages:			
Builders' Iron Foundry	42	30	14
Robt. Poole & Son Company	72	39	33
Morgan Engineering Company	12	2	10
West Point Foundry Company	14	.....	14
Total	142	71	71
Brackets:			
Builders' Iron Foundry	44	23	21
Robt. Poole & Son Company	72	27	45
Morgan Engineering Company	12	4	8
West Point Foundry Company	14	.....	14
Total	142	54	88

Shipments made by Benj. Atha & Illingworth Company, Newark, N. J.

STEEL FORGINGS.

	Pieces.	Weight.
		Pounds.
Builders' Iron Foundry, Providence, R. I.	738	122,047
Robt. Poole & Son Company, Baltimore, Md.	929	158,251
West Point Foundry Company, Cold Spring, N. Y.	191	25,708
Morgan Engineering Company, Alliance, Ohio	240	34,776
Grand total	2,098	340,782

STEEL CASTINGS.

	Pieces.	Weight.		Pieces.	Weight.
Builders' Iron Foundry, Providence, R. I.:		*Pounds.*	West Point Foundry Company, Cold Spring, N. Y.:		*Pounds.*
Trunnions	33	31,509	Trunnions	4	3,760
Cylinders	29	28,911	Cylinders	2	1,896
Brackets	28	7,092	Brackets	3	743
Flanges	22	910	Flanges	6	261
Total	112	68,422	Total	15	6,660
Robert Poole & Son Company, Baltimore, Md.:			Morgan Engineering Company, Alliance, Ohio:		
Trunnions	46	43,972	Trunnions	6	5,686
Cylinders	30	30,071	Cylinders	9	8,982
Brackets	29	7,425	Brackets	4	993
Flanges	36	1,438	Flanges	6	253
Total	141	82,906	Total	25	15,914
			Grand total	293	173,902

RÉSUMÉ.

	Pieces.	Weight.
		Pounds.
Total number of steel forgings	2,098	340,782
Total number of steel castings	293	173,902
Grand total	2,391	514,684

Total number of trunnions	89
Total number of cylinders	70
Total number of brackets	64
Total number of flanges	70
Total castings shipped	293

	Number required.	Number shipped.	Still due.
Flanges:			
Builders' Iron Foundry	22	9	13
Robt. Poole & Son Company	36	8	28
Morgan Engineering Company	6	1	5
West Point Foundry Company	7	.....	7
Total	71	18	53

It is very probable that one set of castings has been shipped to the West Point Foundry, but has not yet been reported.

This company has had a great deal of trouble with their steel castings. The difficulties have been lack of experience with Government work, and absence of a well-defined scientific policy of administration and practice in the steel-casting department. The incompleteness and inadequacy of the present specifications were never more clearly shown than in the execution of these orders. So far in this work 520 test specimens have been broken. The weights of forgings and castings shipped have not yet been reported to this office.

The following tables are appended to and form part of this report, viz: Table I.—Tensile tests—miscellaneous steel forgings, wrought iron, from Pencoyd Iron Works. Table II.—Tensile tests—traversing rollers. Table III.—Tensile tests—hydraulic cylinders (steel castings). Table IV.—Tensile tests—trunnion carriages (steel castings).

Respectfully submitted.

D. A. LYLE,
Captain, Ord. Dept., U. S. Army, Inspector.

CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage.

TABLE I.—MISCELLANEOUS STEEL FORGINGS.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Piston rods (forged steel No. 3).	*Pounds.*	*Pounds.*					
25528	12 C 1 P R—L_1	55,000	86,500	30.20	50.33		Silky	Accepted 28 piston rods.
25529	12 C 10 P R—L_1	60,000	92,000	27.00	46.03		do	
25544	12 C 19 P R—L_1	55,000	85,000	30.90	51.97		do	
25530	12 C 28 P R—L_1	61,500	87,500	27.00	52.77		do	
26116	12 C 29 P R—L_1M	50,000	85,500	23.50	41.89		do	Re-treated.
26408	12 C 30 P R—L_1M	55,000	87,000	27.20	48.32		do	Rejected.
26117	12 C 39 P R—L_1M	55,000	89,500	22.00	39.44		do	Re-treated.
26409	12 C 40 P R—L_1M	53,500	85,000	28.20	50.57		do	Accepts piston rod No. 39.
26118	12 C 49 P R—L_1M	58,000	88,500	28.00	54.41		do	Re-treated.
26410	12 C 50 P R—L_1M	55,500	86,250	28.90	54.66		do	Rejected.
26119	12 C 59 P R—L_1M	51,500	83,000	28 70	54.11		do	Re-treated.
26411	12 C 60 P R—L_1M	53,500	83,500	27.80	58.56		do	Rejected.
26140	12 C 69 P R—L_1M	54,500	89,500	22.00	38.84		do	Accepts piston rod No. 69.
26120	12 C 79 P R—L_1M	55,500	89,000	26.50	49.17		do	Accepts piston rod No. 79.
26121	12 C 89 P R—L_1M	53,000	85,000	26.50	50.57		do	Rejected.
26122	12 C 99 P R—L_1M	49,000	83,000	27.00	52.52		do	Do.
26125	12 C 119 P R—L_1M	53,000	84,000	27.60	51.97		do	Do.
26124	12 C 128 P R—L_1M	52,500	84,500	28.00	49.17		do	Do.
26600	12 C 30 P R—L_2M	72,500	110,000	18.00	43.08		do	Rejected second test after heating and rehammering.
26617	12 C 40 P R—L_2M	76,000	113,500	16.20	36.64		do	
26623	12 C 50 P R—L_2M	60,000	81,500	3.00	3.94		do	
26601	12 C 60 P R—L_2M	73,000	114,500	16.60	38.84		do	
	Piston rods (new lot).							
27001	12 C 40 P R—L_1M	57,000	97,500	17.30	26.46		Silky, granular rim	Accepts piston rods Nos. 29 to 38, inclusive.
27002	12 C 50 P R—L_1M	56,000	99,000	17.80	27.51		Granular, silky spot on side.	Accepts piston rods Nos. 40 to 48 and 50.
27139	12 C 60 P R—L_1M	53,500	99,000	19.20	31.15		Silky, granular rim	Accepts piston rods Nos. 51 to 60, inclusive.

27227	12 C 70 P R—L_1M	59,000	99,500	18.50	30.85		Granular, silky spot on side.	Accepts piston rods Nos. 61 to 70, inclusive.
27222	12 C 80 P R—L_1M	62,000	100,500	23.30	36.64		Silky	Accepts piston rods Nos. 71 to 80, inclusive.
27223	12 C 90 P R—L_1M	56,500	99,000	20.80	35.70		do	Accepts piston rods Nos. 81 to 90, inclusive.
27226	12 C 100 P R—L_1M	59,000	95,500	19.90	29.85		do	Accepts piston rods Nos. 91 to 100, inclusive.
27140	12 C 110 P R—L_1M	58,000	96,000	22.00	33.10		Silky, shearing	Accepts piston rods Nos. 101 to 110, inclusive.
27203	12 C 120 P R—L_1M	62,000	99,000	22.25	43.38		Silky	Accepts piston rods Nos. 111 to 120, inclusive.
27204	12 C 130 P R—L_1M	59,000	98.750	22.50	36.30		Silky, granular specks	Accepts piston rods Nos. 121 to 130, inclusive.
27225	12 C 140 P R—L_1M	62,000	100,000	20.30	35.05		Silky	Accepts piston rods Nos. 131 to 140, inclusive.
27224	12 C 142 P R—L_1M	55,000	94,000	21.00	32.45		do	Accepts piston rods Nos. 141 to 146, inclusive.
	Elevating rack pinion shafts (forged steel No. 2).							
25545	12 C 1 E R P S H—L_1	39,000	65,000	35.70	50.87		Silky	Accepts Nos. 1 to 28 after official tests and annealing.
25546	12 C 10 E R P S H—L_1	37,000	65,000	31.80	48.62		do	
25789	12 C 11 E R P S H—L_1	51,000	71,250	27.00	42.78		do	
25547	12 C 28 E R P S H—L_1	38,000	65,500	35.30	57.81		do	
26126	12 C 29 E R P S H—L_1	37,500	63,750	28.70	39.74		do	
26141	12 C 39 E R P S H—L_1	41,500	61,000	31.80	51.12		do	
26127	12 C 49 E R P S H—L_1	46,500	62,000	32.70	53.87		do	
26128	12 C 59 E R P S H—L_1	34,000	59,000	28.50	43.38		do	
26142	12 C 69 E R P S H—L_1	40,500	64,500	31.50	54.41		do	Condemned.
26143	12 C 79 E R P S H—L_1	40,000	63,250	31.00	51.42		do	
26129	12 C 89 E R P S H—L_1	45,500	66,500	31.50	54.91		do	
26144	12 C 99 E R P S H—L_1	38,250	64,700	31.60	48.92		do	
26145	12 C 109 E R P S H—L_1	36,000	61,000	29.50	48.03		do	
26130	12 C 121 E R P S H—L_1	38,000	66,500	25.50	40.99		do	
	Elevating rack pinion shafts (forged steel No. 2).							
26412	12 C 30 E R P S H—L_1	55,000	75,000	29.50	59.86		Silky	Accepted. Second test after official test and annealing.
26618	12 C 40 E R P S H—L_1	53,500	81,000	19.30	43.98		do	
26619	12 C 50 E R P S H—L_1	55,500	79,000	27.60	50.87		do	
26620	12 C 60 E R P S H—L_1	56,000	78,750	26.30	59.86		do	
26621	12 C 70 E R P S H—L_1	55,500	81,000	22.30	49.72		do	
26604	12 C 80 E R P S H—L_1	56,500	77,500	28.00	54.11		do	
26606	12 C 90 E R P S H—L_1	56,000	81,250	25.00	55.71		do	
26602	12 C 100 E R P S H—L_1	53,000	71,000	31.00	61.36		do	
26605	12 C 110 E R P S H—L_1	55,000	81,000	25.50	52.52		do	
26622	12 C 120 E R P S H—L_1	57,500	83,500	22.00	55.71		do	

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE I.—MISCELLANEOUS STEEL FORGINGS—Continued.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Elevating rack pinion shafts (second lot).	*Pounds.*	*Pounds.*					
26618	12 C 40 E R P—L_1	53,500	81,000	19.30	43.98		Silky	
26619	12 C 50 E R P—L_1	55,500	79,000	27.60	50.87		do	
26620	12 C 60 E R P—L_1	56,000	78,750	26.30	59.86		do	
26621	12 C 70 E R P—L_1	55,500	81,000	22.30	49.92		do	
26604	12 C 80 E R P—L_1	56,500	77,500	28.00	54.11		do	Accepted.
26606	12 C 90 E R P—L_1	56,000	81,250	25.00	55.71		do	
26602	12 C 100 E R P—L_1	53,000	71,000	31.00	61.36		do	
26605	12 C 110 E R P—L_1	55,000	81,000	25.50	52.52		do	
26622	12 C 120 E R P—L_1	57,500	83,500	22.00	55.71		do	
26991	12 C 70 P—L_1M	47,500	72,500	34.25	51.97		do	
26992	12 C 80 P—L_1M	48,000	74,500	27.50	46.03		do	
26993	12 C 90 P—L_1M	51,000	75,000	31.00	56.01		do	
26994	12 C 100 P—L_1M	43,500	71,500	33.25	44.88		Silky, shearing	Accepted.
26995	12 C 110 P—L_1M	45,500	74,000	25.75	37.24		do	
26996	12 C 120 P—L_1M	48,000	72,000	30.60	56.01		do	
26997	12 C 128 P—L_1M	48,500	72,500	32.30	59.61		Silky	
	Traversing worms (forged steel No. 2).							
26191	12 C 1 T W—T_1M	35,500	60,000	17.50	20.22		Granular	
26192	12 C 22 T W—T_1M	37,000	64,500	27.00	39.74		Silky	
26193	12 C 23 T W—T_1M	36,000	62,500	23.00	28.85		do	Non-accepted.
26146	12 C 38 T W—T_1M	33,000	61,500	21.00	20.62		Granular	
	Traversing worms (second lot).							
26624	12 C 1 T W—T_1M	45,750	57,500	2.30	2.75		Granular	
26641	12 C 10 T W—T_2M	45,000	64,000	2.40	3.54		Granular; broke pulling	
26665	12 C 20 T W—T_1M	42,000	79,500	17.00	20.97		Granular, silky spot on side.	Second lot condemned.
26642	12 C 30 T W—T_1M	44,000	85,000	13.70	16.67		do	
26643	12 C 40 T W—T_1M	43,500	82,000	18.50	21.32		Granular; laminated on one side.	

26634	12 C 50 T W—T_1M	47,500	83,000	17.00	23.06	.....	..... do	Second lot condemned.
26644	12 C 60 T W—T_1M	45,000	78,750	7.70	8.53	.....	..... do	
	Traversing worms and hand-wheel pinions.							
27384	12 C 1 P—T_1M	48,000	80,000	24.60	39.44	.....	Silky	Accepts 57 traversing worms and 118 hand-wheel pinions Nos. 1 to 57 T W's, inclusive, and Nos. 1 to 118 H W P's, inclusive.
27385	12 C 10 P—T_1M	48,500	80,500	26.00	41.89	.....	..... do	
27386	12 C 20 P—T_1M	47,000	76,000	11.25	11.53	.....	Fine granular	
27387	12 C 30 P—T_1M	46,650	80,000	26.50	40.34	.....	Silky	
27388	12 C 40 P—T_1M	48,000	81,000	25.30	40.34	.....	..... do	
27389	12 C 50 P—T_1M	48,000	80,500	26.30	43.38	.....	..... do	
27390	12 C 60 P—T_1M	47,500	75,000	14.10	17.02	.....	Granular, silky spot	
	Shafts (forged steel No. 2).							Accepts: 36 sets spring compression screws, 13 pieces, $3\frac{5}{16}$ by 8 feet. 22 shafts for elevating hand-wheel, $2\frac{3}{16}$ round by 8 feet 10 inches. 1 forging washer for elevating hand-wheel, $3\frac{9}{16}$ inches round by 16 feet. 1 forging for washers, elevating pinion, $2\frac{9}{16}$ inches by 16 feet. 38 vertical training shafts, $3\frac{1}{16}$ inches by 5 feet $9\frac{3}{8}$ inches. 38 worm shafts, $2\frac{1}{16}$ inches by 9 feet $2\frac{3}{4}$ inches. 38 screw shafts, $2\frac{1}{16}$ inches by 9 feet $3\frac{1}{8}$ inches. 7 rock shafts for loading mechanism, $3\frac{9}{16}$ inches by 11 feet. 4 taper pins for rock shaft, $1\frac{3}{16}$ inches by 6 feet 6 inches. 7 $2\frac{1}{4}$-inch studs for curved lever, $2\frac{5}{16}$ inches by 5 feet. 40 $1\frac{3}{4}$-inch spring compression bolts, $1\frac{3}{4}$ inches round by 16 feet. 22 loading-mechanism shafts (1 piece 7 shafts, 1 piece 1 shaft, 2 pieces 14 shafts), $3\frac{1}{2}$ inches round by 1 foot $9\frac{1}{2}$ inches. 22 scoop studs (1 4 studs, 1 18 studs) $2\frac{1}{4}$ inches by $9\frac{1}{8}$ inches. 44 spring compression screws (4 pieces, 44 screws), $3\frac{1}{4}$ inches by 1 foot $4\frac{3}{4}$ inches. 22 training worm shafts (22 pieces), 2 inches round by 9 feet 2 inches. 44 hand-wheel shafts (44 pieces), $1\frac{5}{8}$ inches round by 2 feet $2\frac{7}{8}$ inches. 22 vertical training shafts (22 pieces), $3\frac{1}{4}$ inches round by 5 feet $8\frac{7}{8}$ inches. 22 loading screws (22 pieces), $3\frac{1}{4}$ inches by 9 feet $1\frac{1}{4}$ inches.
26113	12 C 1 S H—L_1M	47,500	73,500	27.30	43.68	.....	Silky	
26114	12 C 50 S H—L_1M	49,500	74,500	30.80	49.72	.....	..... do	
26115	12 C 70 S H—L_1M	45,000	73,250	31.00	49.47	.....	..... do	
	Loading mechanism shaft (rolled).							
26110	12 C 1 L M—L_1M	53,500	80,250	27.30	42.48	.....	Silky	
26111	12 C 100 L M—L_1M	46,500	78,000	25.50	44.33	.....	..... do	
26112	12 C 132 L M—L_1M	48,000	77,000	24.00	36.64	.....	..... do	

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE I.—MISCELLANEOUS STEEL FORGINGS—Continued.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section,]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Keys for elevated gear bracket.	*Pounds.*	*Pounds.*					
26964	12 C 1 K—L_1 M, $\frac{1}{4}$ by $\frac{7}{8}$ inch	51,500	80.000	28.00	41.89	.....	Silky	Accepts keys, 20 pieces.
26965	12 C 7 K P R—L_1 M, $2\frac{1}{4}$ by $\frac{13}{16}$ inch.	57,000	81,000	22.00	29.85	.....	Silky, shearing	Accepts keys, 7 pieces.
	Loading screws and vertical training shaft.							
26986	12 C 1 L S—L_1 M	41,500	72,500	30.00	50.57	.....	Silky	Accepts loading screws Nos. 1 to 6, inclusive.
26987	12 C 1 V T S—L_1 M.....	44,000	71,000	33.00	57.31	.....	....do	Accepts vertical training shaft Nos. 1 to 7, inclusive.
	Scoop studs, etc.							
26969	12 C 1 S S—L_1 M.....	60,500	109,500	17.00	27.51	.....	Granular, silky spot on rim .	Accepts scoop studs Nos. 1 to 7, inclusive, and spring compression screws Nos. 1 to 14, inclusive.
26966	12 C 5 S S—L_1 M.....	61,000	112,000	17.80	28.51	.....	.....do	Accepts loading mechanism shafts Nos. 1 to 7, inclusive; training worm shafts, Nos. 1 to 7, inclusive, and loading screws Nos. 1 to 7, inclusive.
26967	12 C 7 S S—L_1 M.....	61,500	110,000	20.00	36.94	.....	Dark, silky, granular rim . .	Accepts hand wheels Nos. 1 to 14, inclusive, and spring compression bolts Nos. 1 to 7, inclusive.
	Six sets rolled stock for Morgan Engineering Company.							
26633	12 C 1 R D M—L_1.....	66,000	109,500	19.20	35.70	.....	Dark, smoky, granular specks.	Accepts 12 pieces $1\frac{5}{8}$ inches round by 2 feet $2\frac{7}{8}$ inches long, 6 pieces 2 inches round by 9 feet 2 inches long, 6 pieces $2\frac{1}{4}$ inches round by $9\frac{1}{8}$ inches long, 12 pieces $3\frac{1}{4}$ inches round by 1 foot $4\frac{3}{4}$ inches long, 6 pieces $3\frac{1}{2}$ inches round by 1 foot $9\frac{1}{8}$ inches long; total, 42 pieces.

								Accepts—			
								Rounds.		Flats.	
								Size (inches).	Number of feet.	Size (inches).	Number of feet.
	Wrought-iron, from Pencoyd Iron Works, for Robt. Poole & Son Company, Baltimore, Md.										
25723	P C D—A, ¾ inch round	45,500	55,000	34.40	44.33		Dark, smoky	$\frac{9}{16}$	150	1 by $\frac{3}{8}$	100
25740	P C D—B, 1⅜ inches round	41,000	52,500	36.00	47.18		Silky	$1\frac{3}{16}$	300	1½ by 1	200
25741	P C D—C, 1¼ inches round	37,000	51,000	34.60	51.12		do	$1\frac{7}{16}$	1,000	2 by ¼	500
25899	P C D—D, 1⅜ inches round	33,250	53,500	32.40	46.03		do	$1\frac{7}{8}$	500	2 by $\frac{5}{16}$	600
25905	P C D—F, 2 by $\frac{5}{16}$ inches flat	38,216	57,643	28.20	30.89		do	1	500	2½ by $\frac{3}{16}$	200
25893	5 P C D_1—L_1 O, 5 by 1 inches flat by 17 feet 9 inches.	31,500	52,000	32.00	33.76			$1\frac{1}{8}$	800	2½ by $\frac{7}{16}$	100
25894	5 P C D_1—L_2 M	29,000	49,000	19.00	29.85			$1\frac{3}{16}$	300	2½ by 1¼	100
25895	5 P C D_2—L_1 O, 5 by 1 inches flat by 20 feet 9 inches.	34,500	53,000	35.80	52.22			$1\frac{1}{4}$	2,000	2½ by 1½	100
25896	L_2 M	28,000	47,500	22.00	29.15			$1\frac{5}{16}$	800	3 by $\frac{7}{16}$	150
25897	5 P C D_6—L_1 O 5 inches square	28,000	49,500	33.50	49.72			$1\frac{3}{8}$	250	3 by 1¾	100
25898	T_1 O	25,000	40,500	8.50	12.28	Transverse bar 5 inches from end, corner.		$1\frac{1}{2}$	500	3¼ by 3¼	75
								$1\frac{9}{16}$	300	4 by $\frac{3}{8}$	200
								$1\frac{3}{4}$	300	4 by 1	100
								4	6 bars.	4½ by 1½	100
										4½ by 3	125
										5 by 5	125
										9 by ¾	200
										5 by 1 72 pieces.	20¾
										5 by 1 72 pieces.	17½
	Wrought-iron, from Pencoyd Iron Works, for Morgan Engineering Company, Alliance, Ohio.										
	P C D—G O	32,250	49,500	24.50	20.62			Accepts 24 bars 5 inches by 1 inch, l. 5½ inches, 12 bars 5 inches by 1 inch, l. 16 feet 8 inches; 12 bars 5 inches by 1 inch, l. 19 feet 11 inches.			
	P C D—G O_2	33,500	52,500	24.50	25.46						
	P C D—I	39,919	50,806	30.80	24.19			Accepts 36 bars 2½ inches by ¼ inch, l. 5 feet 10 inches.			
	P C D—K	36,000	50,965	28.30	21.73						

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE II—STEEL FORGINGS (ROLLERS).

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross-section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Rollers (forged steel No. 3).	*Pounds.*	*Pounds.*					
25790	12 C 63 R—T_1 M	54,500	84,000	7.20	11.88		Granular, silky spot on side.	
25791	12 C 64 R—T_1 M	56,000	89,000	11.00	15.92		Silky, granular rim	
26169	T_2 M, second bar	40,000	76,500	17.00	19.17		Granular	
26160	12 C 44 R—T_1 M	40,000	75,000	21.20	26.81		Silky, granular rim	
26167	12 C 84 R—T_1 M	41,000	59,200	3.00	3.54		Granular	Non-accepted.
26170	12 C 104 R—T_1 M	40,500	73,500	6.50	7.78		Granular; broke at neck, beyond reference mark.	
26161	12 C 124 R—T_1 M	39,500	55,000	3.70	7.38		Granular, silky spot on side; blow-hole.	
26168	12 C 144 R—T_1 M	37,500	71,000	12.50	14.13		Granular	
26466	12 C 36 R—T_1 M	51,500	86,000	12.50	15.23		do	Accepts 24 rollers.
26476	T_2 O	53,500	90,750	13.55	15.23		do	
26793	12 C 37 R—T_1 M, roller	54,000	78,000	14.20	14.83		Fine granular; laminated	Non-accepted.
26870	12 C 64 R—L_1 M, cylinder	50,000	93,500	21.60	34.40	After re-treatment	Silky, granular rim	Accepts 24 rollers.
26759	12 C 70 R—T_1 M	65,500	67,000	.50	5.49		Fine granular; broke pulling.	Non-accepted.
26765	12 C 80 R—T_1 M	60,000	75,000	1.60	2.35		Broke pulling	Do.
26871	12 C 84 R—L_1 M	52,500	93,000	22.20	36.64		Silky, granular spots	Accepts 24 rollers.
26766	12 C 106 R—T_1 M, roller	76,500	97,500	3.70	3.54		Broke pulling	Non-accepted.
26872	L_2 M, second bar	50,000	90,500	23.25	37.89	After re-treatment	Silky, granular specks	Accepts 24 rollers.
26873	12 C 124 R—L_1 O	54,000	92,000	22.60	40.04		do	Do.
26988	12 C 172 R—L_1 M	59,500	91,000	27.00	40.34		Silky	Do.
26989	12 C 192 R—L_1 M	54,000	90,750	24.00	37.24		do	Do.
26990	12 C 212 R—L_1 M	53,500	91,500	24.00	37.89		do	Do.
27363	12 C 250 R—T_1 M	52,250	103,000	9.00	9.28		Fine granular; hard	Non-accepted.
27578	T_2 M	58,000	92,500	(*)	29.50		Silky	Accepts 24 rollers.
27325	12 C 270 R—T_1 M	49,000	100,000	18.50	18.11		Bright granular, silky center.	Do.
27326	12 C 290 R—T_1 M	51,500	103,000	17.50	20.62		Granular, silky center	Do.
27327	12 C 300 R—T_1 M	50,000	89,000	4.50	6.24		Bright granular	Non-accepted.
27823	T_2 M, second bar	59,500	100,000	18.50	28.51	After re-treatment	Granular, silky on side	Accepts 24 rollers.

27328	12 C 330 R—T_1 M	49,500	91,000	5.75	4.29		Bright granular	Non-accepted.
27579	T_2 M, second bar	61,000	101,000	(*)	40.34	After re-treatment	Silky	Accepts 24 rollers.
27329	12 C 350 R—T_1 M	60,000	94,000	20.80	31.50		do	Do.
27787	12 C 370 R—T_1 M	57,500	90,000	25.30	42.48		do	Do.
27493	12 C 390 R—T_1 M	61,000	103,500	21.90	26.81		do	Do.
27788	12 C 410 R—T_1 M	57,000	89,000	25.60	44.88		do	Do.
27494	12 C 430 R—T_1 M	64,000	97,500	13.80	17.77		Silky, shearing	Do.
27789	12 C 450 R—T_1 M	57,000	89,500	25.00	37.89		Silky	Do.
27495	12 C 470 R—T_1 M	62,500	102,000	14.45	17.77		Granular, silky spot on side.	Do.
27790	12 C 490 R—T_1 M	57,000	90,000	23.80	37.24		Silky; cupped	Do.
27496	12 C 510 R—T_1 M	62,500	102,500	20.25	28.51		Silky	Do.
27791	12 C 530 R—T_1 M	57,250	90,000	21.00	32.45		Silky; cupped	Do.
27497	12 C 550 R—T_1 M	60,000	101,000	20.60	36.94		Dark, silky	Do.
27580	12 C 570 R—T_1 M	66,500	102,500	22.10	40.99		Silky	Do.
27580	12 C 590 R—T_1 M	50,500	103,500	13.00	12.28		Granular	Non-accepted.
27792	T_2 M, second bar	61,000	103,500	17.30	31.50	After re-treatment	Granular, silky center	Accepts 24 rollers.
27582	12 C 610 R—T_1 M	50,500	101,500	12.30	15.57		Granular	Non-accepted.
27793	T_2 M, second bar	60,000	101,500	18.50	28.51	After re-treatment	Silky, granular specks	Accepts 24 rollers.
27794	12 C 630 R—T_1 M	56,000	98,000	21.00	36.30		do	Do.
27795	12 C 650 R—T_1 M	57,500	98,500	22.50	37.89		do	Do.
27824	12 C 670 R—T_1 M	62,500	101,500	20.30	29.85		Granular, silky on side	Do.
27796	12 C 690 R—T_1 M	63,500	100,000	17.25	25.81		Silky, granular specks	Do.
27825	12 C 710 R—T_1 M	63,000	103,000	17.00	50.85		Granular, silky on side	Do.
27797	12 C 730 R—T_1 M	63,500	103,000	19.20	34.09		Silky, granular specks	Do.
27826	12 C 750 R—T_1 M	62,000	102,500	19.50	36.00		Silky	Do.
27798	12 C 770 R—T_1 M	61,500	103,500	17.00	35.70		Fine granular, silky center.	Do.
27827	12 C 790 R—T_1 M	61,750	103,000	19.50	38.84		Silky	Do.
27799	12 C 810 R—T_1 M	62,000	105,500	18.60	31.80		Fine granular, silky center.	Do.
27880	12 C 830 R—T_1 M	62,500	104,000	18.70	33.45		do	Do.
27828	12 C 850 R—T_1 M	63,000	104,500	18.70	32.80		Silky, granular rim	Do.
27829	12 C 870 R—T_1 M	63,000	105,500	19.60	35.70		do	Do.
28155	12 C 890 R—T_1 M	60,000	103,200	20.50	36.00		Silky	Do.
28156	12 C 910 R—T_1 M	61,000	103,000	21.20	37.24		do	Do.
28157	12 C 930 R—T_1 M	61,500	102,000	19.00	36.30		do	Do.
28158	12 C 950 R—T_1 M	59,500	102,500	19.00	32.15		Silky, granular	Do.
28159	12 C 970 R—T_1 M	60,500	104,000	19.20	36.64		Silky	Do.
28160	12 C 990 R—T_1 M	60,000	105,500	18.50	36.00		do	Do.
28161	12 C 1010 R—T_1 M	60,500	104,500	19.00	35.35		Silky, granular	Do.
28162	12 C 1030 R—T_1 M	61,500	102,500	17.00	26.81		Granular, silky spots on side.	Do.

* Not taken.

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE III.—STEEL CASTINGS.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Hydraulic cylinders (cast steel No. 2).	*Pounds.*	*Pounds.*					
25285	12 C 1 C—T_1 M	31,000	72,500	23.30	30.85		Granular	Accepts hydraulic cylinder No. 1 and bracket No. 1 B.
25286	L_1 M	37,250	74,000	17.30	22.01		do	
25287	12 C 2 C—T_1 M	34,500	72,000	24.00	30.15		do	Accepts hydraulic cylinder No. 2 and bracket No. 2 B (condemned).
25288	L_1 M	34,500	73,500	20.20	24.06		Silky, granular rim	
25540	12 C 3 C—T_1 M	43,500	85,500	15.70	18.47		Gray, blowy	Accepts hydraulic cylinder No. 3.
25531	L_1 M	44,000	85,000	15.70	19.87		Coarse granular	
25533	12 C 4 C—T_1 M	43,500	85,000	13.00	16.67		Bright granular	Accepts hydraulic cylinder No. 4.
25532	L_1 M	44,500	85,500	19.30	20.62		Coarse granular	
25494	12 C 5 C—T_1 M	39,500	73,000	19.00	21.32		Granular	Accepts hydraulic cylinder No. 5 and brackets Nos. 4 B and 5 B.
25491	L_1 M	34,000	71,000	17.00	18.47		do	
25535	12 C 6 C—T_1 M	41,000	72,500	14.50	16.32		Bright granular	Accepts hydraulic cylinder No. 6 and brackets Nos. 6 B, 11 B, and 12 B.
25534	L_1 M	38,000	72,500	17.00	17.02		do	
25495	12 C 7 C—T_1 M	40,000	74,500	16.40	18.47		Silky	Accepts hydraulic cylinder No. 7 and bracket No. 7 B.
25492	L_1 M	37,000	73,000	13.00	17.02		Granular	
25537	12 C 8 C—T_1 M	38,000	73,000	15.25	17.37		Bright granular	Accepts hydraulic cylinder No. 8.
25536	L_1 M	36,000	71,000	15.50	18.11		do	
25496	12 C 9 C—T_1 M	35,500	61,500	9.20	15.23		Silky	To be retested.
25493	L_1 M	37,000	71,500	14.50	18.47		do	
25539	T_2 M, second time	36,000	73,500	17.50	23.76		Gray, open	Accepts hydraulic cylinder No. 9.
25538	L_2 M, second time	36,500	74,000	20.50	21.66		Bright granular	
25610	12 C 10 C—T_1 M	30,500	65,000	17.50	30.50		Silky	Rejected.
25609	L_1 M	28,000	64,750	26.00	28.85		do	
25612	12 C 11 C—T_1 M	35,000	60,000	17.50	25.46		Granular	Rejected.
25611	L_1 M	30,000	63,000	21.00	24.06		do	
25614	12 C 12 C—T_1 M	31,000	65,000	16.00	20.62		Granular; blow-hole	Rejected.
25613	L_1 M	30,500	68,500	17.00	26.81		Granular	
25616	12 C 13 C—T_1 M	30,500	65,000	10.00	13.38		Granular; broke through blow-hole.	Rejected.
25615	L_1 M	29,000	66,000	18.40	20.62		Granular	
25618	12 C 14 C—T_1 M	26,000	62,500	22.50	32.15		Granular; broke through blow-hole.	Rejected.
25617	L_1 M	28,000	64,500	22.50	29.50		Granular	

25620	12 C 15 C—T_1 M	27,500	37,500	4.50	5.84		Spongy; broke through blow-hole	Rejected.
25619	L_1 M	30,000	67,500	23.80	37.24		Silky	
25622	12 C 16 C—T_1 M	31,000	39,000	7.00	14.13		Spongy; broke through blow-hole.	Rejected.
25621	L_1 M	29,000	66,500	24.80	30.85		Granular	
25860	12 C 17 C—T_1 M	27,500	66,500	18.50	21.66		do	Rejected.
25859	L_1 M	29,000	66,500	21.00	23.41		do	
25862	12 C 18 C—T_1 M	28,500	66,500	28.00	37.89		do	Rejected.
25861	L_1 M	32,750	70,500	13.50	18.47		Granular; broke through blow-hole in fillet.	
25864	12 C 19 C—T_1 M	27,750	65,250	15.80	14.83		Granular	Rejected.
25863	L_1 M	32,500	67,000	9.00	12.63		Granular; broke through blow-hole in fillet.	
	Hydraulic cylinders (cast steel No. 2).							
25759	12 C 22 C—T_1 M	28,250	63,750	21.00	32.15		Granular	Rejected hydraulic cylinder No. 22.
25760	L_1 M	27,500	62,000	17.50	17.17		do	
25761	12 C 23 C—T_1 M	29,750	67,500	25.50	35.35		Silky	Rejected hydraulic cylinder No. 23.
25762	L_1 M	29,000	67,000	20.50	25.81		Granular	
25763	12 C 24 C—T_1 M	33,500	73,500	17.00	18.11		do	Accepts hydraulic cylinder No. 24.
25764	L_1 M	30,750	70,500	15.00	15.23		do	
26072	12 C 25 C—T_1 M	28,000	59,500	10.50	20.62		Granular	Rejected hydraulic cylinder No. 25.
26073	L_1 M	29,000	65,000	15.70	19.52		do	
26074	12 C 26 C—T_1 M	32,000	64,500	8.80	10.78		do	Rejected hydraulic cylinder No. 26.
26075	L_1 M	30,000	65,500	16.40	24.76		do	
26076	12 C 28 C—T_1 M	31,000	67,000	22.50	27.85		do	Rejected hydraulic cylinder No. 28. Accepts brackets 17 B, 18 B, 19 B, and 20 B.
26077	L_1 M	29,000	66,000	15.50	19.52		do	
26078	12 C 29 C—T_1 M	29,500	67,500	15.30	18.11		do	Rejected hydraulic cylinder No. 29.
26079	L_1 M	30,000	66,500	11.50	15.57		do	
26080	12 C 30 C—T_1 M	30,000	68,000	15.00	14.83		do	Rejected hydraulic cylinder No. 30.
26081	L_1 M	29,500	64,500	10.50	11.88		do	
26082	12 C 31 C—T_1 M	30,500	66,500	16.50	18.11		do	Rejected hydraulic cylinder No. 31. Accepts brackets 21 B, 22 B, 23 B, and 24 B.
26083	L_1 M	30,500	66,000	19.60	25.81		do	
26084	12 C 32 C—T_1 M	30,500	66,500	17.80	18.11		do	Rejected hydraulic cylinder No. 32.
26085	L_1 M	31,000	67,000	8.20	8.53		Granular; broke through reference marks.	
26086	12 C 33 C—T_1 M	31,500	68,000	20.00	23.76		Granular	Rejected hydraulic cylinder No. 33.
26087	L_1 M	30,000	66,500	16.50	20.62		do	
25986	12 C 35 C—T_1 M	30,000	67,000	6.60	8.13		Bright granular; broke pulling.	Too hard, No. 35.
25987	L_1 M	32,000	70,500	11.00	15.23		Granular	
26554	T_2 M, second time	31,000	73,000	19.50	27.51		Gray, with crystalline rim	Accepts hydraulic cylinder No. 35.
26511	L_2 M, second time	31,000	71,500	12.30	15.23		Coarse crystals	
25988	12 C 36 C—T_1 M	32,500	74,000	22.00	26.17		Granular, silky spot on side	Accepts hydraulic cylinder No. 36.
25989	L_1 M	30,500	69,000	13.40	17.37		Granular	
25990	12 C 37 C—T_1 M	34,500	74,500	13.20	14.48		do	Accepts hydraulic cylinder No. 37.
25991	L_1 M	30,000	73,000	16.00	17.37		do	

Hydraulic cylinders Nos. 20 and 21 were scrapped, but not tested.

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE III.—STEEL CASTINGS—Continued.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, retreatment, etc.
	Hydraulic cylinders (cast steel No. 2)—Continued.	*Pounds.*	*Pounds.*					
26013	12 C 38 C—T_1 M	34,250	72,000	13.20	14.13		Granular	Accepts hydraulic cylinder No. 38.
26014	L_1 M	32,500	74,000	16.40	17.37		do	
25992	12 C 39 C—T_1 M	32,000	73,500	12.30	13.38		do	Too hard, No. 39.
25993	L_1 M	32,000	70,500	12.00	10.38		do	
26553	T_2 M, second time	31,000	72,500	12.10	11.53		Very bright crystals	Accepts hydraulic cylinder No. 39.
26518	L_2 M, second time	31,500	73,000	20.25	22.71		Coarse crystals	
25994	12 C 40 C—T_1 M	31,500	74,000	13.50	17.37		Granular	Accepts hydraulic cylinder No. 40.
25995	L_1 M	31,500	73,500	18.60	21.66		do	
26015	12 C 41 C—T_1 M	33,000	73,500	15.50	15.23		do	Accepts hydraulic cylinder No. 41.
26016	L_1 M	35,500	73,500	15.60	17.77		do	
25996	12 C 42 C—T_1 M	32,500	71,500	8.90	11.53		do	Too hard, No. 42.
25997	L_1 M	35,000	70,500	9.80	13.03		do	
26555	T_2 M, second time	32,000	70,000	7.90	9.28		Bright, coarse granular	Rejected hydraulic cylinder No. 42.
26519	L_2 M, second time	32,500	70,000	11.00	12.63		Very bright crystals	
26556	12 C 43 C—T_1 M	35,500	75,000	16.00	15.57		Bright granular	Accepts hydraulic cylinder No. 43.
26520	L_1 M	37,500	75,000	14.20	16.32		Crystalline defect at edge	
26549	12 C 44 C—T_1 M	38,000	76,000	15.20	16.32		Bright granular; laminated.	Accepts hydraulic cylinder No. 44.
26521	L_1 M	38,000	73,000	12.55	16.67		Gray, open, crystalline edge.	
26321	12 C 45 C—T_1 M	46,500	83,000	12.40	18.82		Silky	Too hard, No. 45.
26322	L_1 M	49,500	83,250	10.50	13.73		Silky, granular	
26532	T_2 M, second time	50,000	79,000	15.00	18.11		Granular rim	Accepts hydraulic cylinder No. 45.
26529	L_2 M, second time	48,500	79,000	13.00	15.92		Open, crystalline gray side	
26329	12 C 46 C—T_1 M	50,000	82,000	10.00	14.83		Silky, granular rim	Too hard, No. 46.
26330	L_1 M	50,000	86,000	15.00	15.23		do	
26557	T_2 M, second time	50,000	79,500	13.60	16.67		Earthy, granular specks	Rejected hydraulic cylinder No. 46.
26522	L_2 M, second time	52,000	81,500	10.60	13.38		Gray, open	
26323	12 C 47 C—T_1 M	49,500	83,000	13.00	20.22		Silky	Accepts hydraulic cylinder No. 47.
26324	L_1 M	49,000	85,000	17.00	19.17		Silky, granular rim	
26428	12 C 48 C—T_1 M	40,000	82,000	8.00	7.78	Broke in thread, scant stock in coupon.	Shearing	Accepted on fracture and test from same heat. Accepts hydraulic cylinder No. 48.
26418	L_1 M	40,000	87,500	13.70	17.37		Granular	

26426	12 C 49 C—T_1M	43,000	85,500	18.00	23.06		Granular	Accepts hydraulic cylinder No. 49.
26419	L_1M	40,000	87,000	17.70	28.16		do	
26427	12 C 50 C—T_1M	45,000	86,000	20.00	27.16		Silky, granular rim	Accepts hydraulic cylinder No. 50.
26417	L_1M	43,500	86,000	16.60	24.41		Granular	
26427	12 C 51 C—T_1M	42,000	84,500	19.00	29.85		Silky, granular rim	Accepts hydraulic cylinder No. 51.
26416	L_1M	41,000	87,500	11.50	13.75		Earthy	
26325	12 C 52 C—T_1M	43,500	77,000	15.00	19.87		Silky	Accepts hydraulic cylinder No. 52.
26326	L_1M	37,500	77,750	15.30	18.47		do	
26327	12 C 53 C—T_1M	42,500	75,000	13.00	18.82		do	Accepts hydraulic cylinder No. 53.
26328	L_1M	42,750	76,500	14.50	21.66		do	
26530	12 C 54 C—T_1M	40,000	75,000	15.00	15.92		Fine crystalline gray spots.	Accepts hydraulic cylinder No. 54.
26531	L_1M	38,500	73,500	16.75	11.88		Granular, silky spot on rim.	
26550	12 C 55 C—T_1M	37,000	77,000	17.00	20.22		Granular, silky spot on edge.	Accepts hydraulic cylinder No. 55, and brackets Nos. 31 B, 32 B, and flanges Nos. 9, 10, 11, and 12 F.
26523	L_1M	36,000	74,000	14.10	15.92		Very bright crystalline defect at edge.	
27127	12 C 56 C—T_1M	44,000	80,000	10.00	12.63		Granular	Too hard, No. 56.
27060	L_1M	43,000	83,000	11.00	12.63		Granular; broke pulling	
27658	T_2M, second time	41,500	81,500	14.00	16.67		Fine granular, silky spot on side.	Accepts hydraulic cylinder No. 56.
27591	L_2M, second time	43,000	82,500	17.30	18.47		Granular, silky spot on side.	
27257	12 C 57 C—T_1M	41,500	85,500	14.50	17.02		do	Accepts hydraulic cylinder No. 57.
27237	L_1M	42,000	85,000	18.40	19.52		Granular	
27258	12 C 58 C—T_1M	41,000	84,500	16.50	20.62		Granular, silky specks	Accepts hydraulic cylinder No. 58.
27246	L_1M	39,750	86,000	21.40	32.45		Silky, granular rim	
27259	12 C 59 C—T_1M	40,500	85,500	14.75	15.92		Granular, silky spots	Accepts hydraulic cylinder No. 59.
27245	L_1M	39,500	86,500	20.50	26.81		Silky, granular rim	
27257	12 C 60 C—T_1M	41,500	82,000	12.00	14.13		Granular	Accepts hydraulic cylinder No. 60.
27247	L_1M	40,000	86,000	20.00	22.71		Silky, granular rim	
27260	T_2M, extra bar	41,000	73,000	7.50	8.53	Blow-hole in bar	Bright granular, silky spots.	
27100	12 C 61 C—T_1M	46,500	82,000	12.10	16.67		Silky, granular rim	Too hard, No. 61.
27061	L_1M	43,500	83,500	12.00	13.38		Granular	
27670	T_2M, second time	43,500	81,000	12.00	13.03		Granular, silky spot on side.	
27592	L_2M, second time	41,000	77,500	6.70	12.63	Broke through large blow-hole; visible before testing.	Granular	Rejected hydraulic cylinder No. 61.
27659	12 C 62 C—T_1M	42,750	83,500	17.25	19.87		Fine granular, silky spot on side.	Accepts hydraulic cylinder No. 62.
27593	L_1M	42,000	83,500	15.60	20.62		Granular, silky spot on side.	
27098	12 C 63 C—T_1M	44,000	82,500	10.80	13.03		do	Too hard, No. 63.
27062	L_1M	42,000	82,500	12.00	14.13		Granular	
27660	T_2M, second time	44,000	84,500	17.25	18.82		Fine granular, silky spot on side.	Accepts hydraulic cylinder No. 63.
27594	L_2M, second time	43,500	84,000	13.00	19.17		Granular, silky spot on side.	
27105	12 C 64 C—T_1M	47,000	82,000	14.00	18.11		do	Accepts hydraulic cylinder No. 64.
27063	L_1M	43,000	82,500	15.50	17.77		Granular	
27661	12 C 65 C—T_1M	40,000	83,500	12.50	14.53		Granular, silky center	Accepts hydraulic cylinder No. 65.
27595	L_1M	39,500	85,000	18.30	23.76		Granular, silky spot on side	
27261	12 C 66 C—T_1M	42,000	86,000	16.25	11.53		Bright granular, silky spots.	Accepts hydraulic cylinder No. 66.
27238	L_1M	41,000	88,500	17.40	20.62		Granular	

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE III.—STEEL CASTINGS—Continued.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Hydraulic cylinders (cast steel No. 2)—Continued.	*Pounds.*	*Pounds.*					
27259	12 C 67 C—T_1 M	43,500	85,000	11.20	13.38		Granular	Accepts hydraulic cylinder No. 67.
27238	L_1 M	43,500	87,500	19.90	24.06		do	
27262	T_2 M, extra bar	43,500	86,000	21.00	18.82		Bright granular, silky spot on side.	
27263	12 C 68 C—T_1 M	44,000	87,500	11.50	11.53		do	Too hard, No. 68.
27248	L_1 M	42,000	90,250	18.00	39.14		Granular	
27264	12 C 69 C—T_1 M	44,500	86,250	10.00	10.00		Bright granular, silky spot on side.	Too hard, No. 69.
27239	L_1 M	44,000	88,000	18.30	22.36		Granular	
27099	12 C 71 C—T_1 M	42,500	79,000	10.40	12.28		Granular, silky spot on side.	Too hard, No. 71.
27102	L_1 M	46,500	82,000	10.00	14.13		Granular	
27662	T_2 M, second time	42,000	83,000	16.25	15.92		Granular, accordeon	Accepts hydraulic cylinder No. 71.
27596	L_2 M, second time	41,000	86,500	19.70	21.66		Granular, silky spot on side.	
27106	12 C 72 C—T_1 M	45,500	81,500	13.50	17.02		Silky, granular rim	Accepts hydraulic cylinder No. 72.
27064	L_1 M	44,000	85,000	18.75	21.32		Fine granular, silky spot on side.	
27107	12 C 73 C—T_1 M	45,500	82,500	20.50	28.51		Silky, granular rim	Accepts hydraulic cylinder No. 73.
27101	L_1 M	44,500	82,500	11.60	15.92		Granular, silky spot on rim.	
27104	12 C 74 C—T_1 M	45,500	82,000	15.40	14.48		Granular, silky on side	Accepts hydraulic cylinder No. 74.
27065	L_1 M	46,000	86,000	18.00	23.41		Fine granular, silky spot on side.	
27126	12 C 75 C—T_1 M	47,000	81,000	15.00	18.82		Earthy	Accepts hydraulic cylinder No. 75.
27066	L_1 M	44,500	85,500	18.10	20.22		Fine granular, silky spot on side.	
27103	12 C 76 C—T_1 M	46,000	82,000	15.60	19.52		Granular; silky on side	Accepts hydraulic cylinder No. 76.
27067	L_2 M	46,000	86,000	20.00	24.06		Fine granular, silky side	
27258	12 C 77 C—T_1 M	43,000	88,000	16.00	17.37		Granular	Accepts hydraulic cylinder No. 77.
27244	L_1 M	44,500	90,000	15.50	22.01		do	
	L_1 O, extra bar	42,250	87,000	19.60	25.46		do	
27627	12 C 78 C—T_1 M	43,000	88,500	19.20	22.01		Granular, silky spot	Accepts hydraulic cylinder No. 78.
27597	L_1 M	44,500	88,500	17.50	22.36		Granular, silky spot on side.	
27260	12 C 79 C—T_1 M	43,500	88,000	16.50	20.97		Granular	Accepts hydraulic cylinder No. 79.
27240	L_1 M	43,000	85,500	15.50	18.82		do	

27626	12 C 80 C—T_1 M	45,000	88,500	16.80	17.37		Granular, silky spot on side.	Accepts hydraulic cylinder No. 80.
27498	L_1 M	45,000	89,000	22.50	29.50		Silky	
27663	12 C 81 C—T_1 M	42,000	80,000	11.00	14.13		Bright granular	Accepts hydraulic cylinder No. 81.
27664	L_1 M	42,500	83,500	23.00	29.85		Granular, silky side	
27665	12 C 82 C—T_1 M	40,500	84,500	14.00	15.57		Bright granular	Accepts hydraulic cylinder No. 82.
27598	L_1 M	40,000	85,000	20.90	25.81		Granular, silky spot on side.	
27666	12 C 83 C—T_1 M	40,500	52,500	6.50	6.99	Broke pulling	Earthy; defect in bar	Accepts hydraulic cylinder No. 83.
27667	L_1 M	42,500	86,000	21.00	29.15		Granular, silky center	
27668	12 C 86 C—T_1 M	42,000	84,500	11.50	11.13		Granular; hard	Accepts hydraulic cylinder No. 86, and brackets Nos. 49, 50, 51, 52, 53, and 54 B, and flanges Nos. 22, 23, 24, and 25 F.
27669	L_1 M	46,250	84,000	21.35	30.50		Fine granular, silky spot	
28180	12 C 19 C—T_2 M, second bar	33,500	71,500	14.13	18.11		Granular	Accepts cylinder No. 19.
28074	L_2 M, second bar	30,500	71,500	24.40	33.10		Silky, granular rim	
28181	12 C 28 C—T_2 M, second bar	32,500	66.000	27.60	36.00			Non-accepts cylinder No. 28.
	L_2 M, second bar	(*)						
28182	12 C 31 C—T_2 M, second bar	36,500	68,500	20.30	23.41		Silky	Accepts cylinder No. 31.
28075	L_2 M, second bar	38,000	70,000	15.00	20.97		Earthy	
28183	12 C 85 C—T_1 M	39,250	80,000	15.80	19.87		Granular, silky spot on side.	Accepts cylinder No. 85.
28076	L_1 M	37,500	80,000	19.80	26.46		do	
28184	12 C 90 C—T_1 M	42,500	82,500	17.50	20.97		Granular	Accepts cylinder No. 90.
28077	L_1 M	39,000	84,500	19 50	23.76		Granular, silky spot on side.	
28185	12 C 91 C—T_1 M	43,500	89,500	18.30	21.66		Granular	Accepts cylinder No. 91.
28078	L_1 M	40,000	90,000	15.60	17.02		Granular, silky spot on side.	
28186	12 C 92 C—T_1 M	41,500	88,000	22.00	31.15		Silky, granular rim	Accepts cylinder No. 92 and brackets 58 B, 59 B, and 60 B.
28079	L_1 M	42,500	91,000	19.60	29.15		Earthy	
28187	12 C 93 C—T_1 M	43,500	88,000	20.30	29.15		Silky, granular rim	Accepts cylinder No. 93 and flanges 26 F, 27 F, 28 F, 29 F, 30 F, 31 F, and 32 F.
28088	L_1 M	40,000	89,500	21.30	28.51		Granular, silky center	
28188	12 C 94 C—T_1 M	42,500	89,000	18.00	26.46		Granular	Accepts cylinder No. 94.
28080	L_1 M	39,600	89,500	20.40	26.81		Granular, silky spot on side.	
28189	12 C 95 C—T_1 M	41,500	87,500	16.60	22.36		Granular	Accepts cylinder No. 95 and brackets 65 B, 66 B, and 67 B.
28081	L_1 M	42,000	89,500	20.40	27.16		Silky, granular rim	
28190	12 C 96 C—T_1 M	43,000	86,000	22.40	26.81		do	Accepts cylinder No. 96, and flanges 33 F, 34 F, 35 F, 36 F, and 37 F.
28082	L_1 M	40,500	89,500	19.20	26.81		do	
	Hydraulic cylinders.							
28191	12 C 97 C—T_1 M	40,500	88,000	20.50	31.15		Silky, granular rim	Accepts cylinder No. 97, and flanges Nos. 38, 39, 40, 41, 42, 43, 44, 45, 46, and 47.
28083	L_1 M	41,500	89,000	20.50	25.81		Granular, silky spot on side	
28192	12 C 98 C—T_1 M	43,500	90,000	16.00	20.62		Granular, silky center	Accepts cylinder No. 98.
28084	L_1 M	40,000	89,500	20.20	24.41		do	
28193	12 C 99 C—T_1 M	42,000	86,500	18.20	25.81		do	Accepts cylinder No. 99.
28085	L_1 M	42,500	88,500	22.30	29.15		Silky, granular rim	
28194	12 C 100 C—T_1 M	41,000	87,500	18.80	19.52		Granular	Accepts cylinder No. 100.
28086	L_1 M	41,500	89,500	20.50	26.17		Granular, silky center	
28195	12 C 200 C—T_1 M	40,500	81,000	16.20	19.17		Granular, silky spot on side.	Accepts cylinder No. 200 and flanges 65, 66, 71, 72, 73, 74, 75, and 76.
28087	L_1 M	36,500	80,500	20.30	21.32		do	
28004	12 C 87 C—T_1 M	38,500	79,500	22.50	23.41		Silky, granular on one side	Accepts cylinder No. 87.
27987	L_1 M	39,000	79,500	18.00	22.01		Granular, silky on side	
28005	12 C 88 C—T_1 M	37,750	80,500	22.40	25.16		Granular, silky spot on rim	Accepts cylinder No. 88.
27988	L_1 M	37,500	80,500	17.80	19.17		Granular, silky spot on side.	

*Porous; bar full of holes; not tested.

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE IV.—STEEL CASTINGS.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Trunnion carriages.	*Pounds.*	*Pounds.*					
25524	12 C 1 T C—L_1 M	32,500	71,000	29.00	40.04		Silky	Accepts trunnion carriage No. 1.
25525	12 C 2 T C—L_1 M	31,500	64,250	10.80	13.38		Coarse granular	Non-accepted No. 2.
25553	L_2 M, second test.	33,500	65,000	12.50	16.67		do	Rejected trunnion carriage No. 2.
25526	12 C 3 T C—L_1 M	45,000	65,000	15.90	19.17		Broke pulling	Accepts trunnion carriage No. 3.
25608	12 C 4 T C—L_1 M	30,000	66,000	21.50	22.71		Granular	Accepts trunnion carriage No. 4.
25799	12 C 5 T C—L_1 M	32,500	71,000	16.00	20.22		do	Accepts trunnion carriage No. 5.
25800	12 C 6 T C—L_1 M	34,000	68,750	10.00	11.13		do	Rejected trunnion carriage No. 6.
25801	12 C 7 T C—L_1 M	32,500	70,500	10.60	14.13		do	Rejected trunnion carriage No. 7.
25802	12 C 8 T C—L_1 M	32,250	70,000	17.00	22.01		do	Accepts trunnion carriage No. 8.
26088	12 C 9 T C—L_1 M	29,000	64,500	11.50	14.13		do	Rejected trunnion carriage No. 9.
	12 C 10 T C							Shipped to Builders' Iron Foundry by order of Builders' Iron Foundry before testing.
26089	12 C 11 T C—L_1 M	28,000	58,500	8.00	13.03		Granular	Rejected trunnion carriage No. 11.
	12 C 12 T C							Were rejected before testing.
	12 C 13 T C							Condemned for defective castings.
	12 C 14 T C							Rejected before testing.
	12 C 15 T C							Condemned for defective casting.
25998	12 C 16 T C—L_1 M	33,000	74,,000	20.50	28.85		Silky, granular rim	Accepts trunnion carriage No. 16.
25999	12 C 17 T C—L_1 M	30,000	69,500	16.50	19.52		Granular	Accepts trunnion carriage No. 17.
26007	12 C 18 T C—L_1 M	31,500	72,500	14.00	14.83		do	Accepts trunnion carriage No. 18, on first bar.
26162	L_2 M, second bar.	31,000	68,000	11.00	10.38		do	
26008	12 C 19 T C—L_1 M	32,000	74,500	19.20	20.22		do	Accepts trunnion carriage No. 19.
26009	12 C 20 T C—L_1 M	34,000	71,000	8.20	8.88		Granular; broke while pulling.	Too hard, No. 20.
26593	L_2 M, second bar.	39,000	72,500	22.00	27.51		Silky	Accepts trunnion carriage No. 20.
26010	12 C 21 T C—L_1 M	32,000	74,500	15.00	15.92		Granular	Accepts trunnion carriage No. 21.
26011	12 C 22 T C—L_1 M	31,750	74,000	14.60	17.02		do	Accepts trunnion carriage No. 22.

26012	12 C 23 T C—L_1 M	32,500	74,000	17.50	19.52	.....	....do	Accepts trunnion carriage No. 23, and bracket No. 27 B, and flanges 6, 7, and 8 F.
26345	12 C 24 T C—L_1 M	42,000	74,500	10.50	16.83	.....	Earthy, granular specks	Too hard, No. 24.
26769	L_2 M, second bar.	39,500	76,000	14.60	21.32	.....	Silky, granular rim	Accepts trunnion carriage No. 24.
26346	12 C 25 T C—L_1 M	44,000	73,750	16.00	13.03	.....	Granular	Accepts trunnion carriage No. 25.
26347	12 C 26 T C—L_1 M	37,500	74,500	14.75	9.63	.....	....do	Accepts trunnion carriage No. 26.
26355	12 C 27 T C—L_1 M	31,750	66,500	21.70	28.85	.....	Silky	Accepts trunnion carriage No. 27.
26348	12 C 28 T C—L_1 M	28,250	67,000	19.00	24.76	.....	Granular, silky spots	Accepts trunnion carriage No. 28.
26356	12 C 29 T C—L_1 M	31,500	63,500	12.00	20.97	.....	Silky	Non-accepts, No. 29.
26400	12 C 29 T C—L_2 M, second bar.	31,000	66,750	19.80	25.16	.....	Earthy	Accepts trunnion carriage No. 29.
26349	12 C 30 T C—L_1 M	32,000	66,500	16.20	20.62	.....	Silky, granular spots	Accepts trunnion carriage No. 30.
26350	12 C 31 T C—L_1 M	28,000	68,000	18.75	17.77	.....	Granular, silky spots	Accepts trunnion carriage No. 31 and bracket No. 28 B, same heat.
26357	12 C 32 T C—L_1 M	40,000	67,000	8.00	14.48	.....	Earthy	Non-accepts, No. 32.
26868	L_2 M, second bar.	43,100	72,500	14.80	17.77	.....	Silky, granular	Accepts trunnion carriage No. 32.
26351	12 C 33 T C—L_1 M	39,500	67,500	8.25	14.83	.....	Silky, granular spots broke in two places.	Non-accepts No. 33.
26770	L_2 M, second bar.	38,500	74,000	13.80	16.32	.....	Silky, granular	Accepts trunnion carriage No. 33.
26358	12 C 34 T C—L_1 M	44,500	70,000	10.50	11.53	.....	Earthy	Non-accepts No. 34.
26760	L_2 M, second bar.	39,500	73,000	14.30	17.02	.....	Granular, silky	Accepts trunnion carriage No. 34.
26352	12 C 35 T C—L_1 M	40,000	65,500	7.25	18.82	.....	Silky, granular spots	Non-accepts No. 35.
26943	L_2 M, second bar.	34,000	68,000	15.50	19.52	.....	Granular, silky spots on rim	Accepts trunnion carriage No. 35.
26359	12 C 36 T C—L_1 M	43,500	70,000	9.00	15.57	.....	Earthy	Non-accepts No. 36.
26512	L_2 M, second bar.	43,000	70,500	18.80	19.17	.....	Fine granular, gray defect on edge.	Accepts trunnion carriage No. 36.
26413	12 C 37 T C—L_1 M	43,250	70,500	9.00	11.53	.....	Earthy	Non-accepts No. 37.
26771	L_2 M, second bar.	43,000	76,500	15.20	16.32	.....	Granular center	Accepts trunnion carriage No. 37.
26414	12 C 38 T C—L_1 M	40,000	68,500	8.00	8.88	.....	Earthy	Non-accepts No. 38.
26767	L_2 M, second bar.	38,500	75,000	13.75	18.47	.....	Granular, silky on side	Accepts trunnion carriage No. 38.
26513	12 C 39 T C—L_1 M	43,500	73,000	10.00	13.38	.....	Gray, open	Non-accepts No. 39.
26768	L_2 M, second bar.	39,500	72,500	11.60	16.32	.....	Granular rim	Rejected trunnion carriage No. 39.
26415	12 C 40 T C—L_1 M	39,000	68,500	7.00	11.53	.....	Earthy	Non-accepts No. 40.
26772	L_2 M, second bar.	40,500	76,000	13.80	17.02	.....	Granular rim	Accepts trunnion carriage No. 40.
26514	12 C 41 T C—L_1 M	37,000	63,000	7.00	10.38	.....	Gray, open, slightly crystallized.	Non-accepts No. 41.
26773	12 C 41 T C—L_2 M, second bar.	37,000	73,000	18.20	19.87	.....	Silky, granular rim	Accepts trunnion carriage No. 41.
26515	12 C 42 T C—L_1 M	39,000	70,500	11.75	15.23	.....	Gray, open, slightly crystallized.	Non-accepts No. 42.
26869	L_2 M, second bar.	42,500	73,000	18.85	26.46	.....	Silky, serrated	Accepts trunnion carriage No. 42.

Benj. Atha & Illingworth Company, Newark, N. J.—Tensile tests for 12-inch mortar spring-return carriage—Continued.

TABLE IV.—STEEL CASTINGS—Continued.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

Mid-vale No.	Marks on specimens.	Elastic limit per square inch of original section.	Ultimate strength per square inch of original section.	Ultimate elongation per inch after rupture.	Reduction in area after rupture, per cent of original section.	Position of rupture.	Character of broken surface, manner of failure, etc.	Remarks relative to acceptance, rejection, re-treatment, etc.
	Trunnion carriages—Cont'd.	*Pounds.*	*Pounds.*					
26774	12 C 43 T C—L_1 M	37,500	70,000	9.80	13.03		Silky	Non-accepts trunnion carriage No. 43.
26774	L_2 M, second bar.	41,000	73,500	16.60	22.71		do	Accepts trunnion carriage No. 43.
26516	12 C 44 T C—L_1 M	35,500	66,000	8.40	9.28		Gray, open	Non-accepts No. 44.
26775	L_2 M, second bar.	37,000	73,600	15.00	17.02		Silky, granular rim	Accepts trunnion carriage No. 44.
26517	12 C 45 T C—L_1 M	41,500	67,000	8.40	13.73		Gray, open; defect	Non-accepts No. 45.
26776	L_2 M, second bar.	35,750	72,500	15.50	21.32		Silky	Accepts trunnion carriage No. 45.
27620	12 C 47 T C—L_1 M	41,500	76,500	22.30	20.22		Granular, silky spot on side.	Accepts trunnion carriage No. 47.
27334	12 C 48 T C—L_1 M	42,500	75,000	22.00	20.62		do	Accepts trunnion carriage No. 48.
27335	12 C 49 T C—L_1 M	40,000	77,000	17.00	18.82		do	Accepts trunnion carriage No. 49.
27336	12 C 50 T C—L_1 M	41,000	76,500	18.75	24.06		Earthy	Accepts trunnion carriage No. 50, also brackets 32 and 33 B, and flanges 13, 14, 15, 16, 17, 18, 19 F, all from same heat.
26594	12 C 51 T C—L_1 M	27,500	51,000	8.00	12.28		Bright granular	Non-accepts No. 51.
26777	L_2 M, second bar.	31,500	62,000	26.80	33.76		Silky	Accepts trunnion carriage No. 51.
26595	12 C 52 T C—L_1 M	25,000	54,000	14.00	17.77		Bright granular	Non-accepts No. 52.
26778	L_2 M, second bar.	32,000	59,500	27.50	36.94		Silky	Accepts trunnion carriage No. 52.
26596	12 C 53 T C—L_1 M	24,500	54,000	11.00	13.38		Bright granular	Non-accepts No. 53.
26779	L_2 M, second bar.	32,000	60,000	22.70	28.16		Silky	Accepts trunnion carriage No. 53 and bracket 38 B.
26598	12 C 54 T C—L_1 M	25,000	57,000	22.50	26.81		Bright granular	Non-accepts No. 54.
26780	L_2 M, second bar.	29,000	60,500	19.40	20.97		Silky	Accepts trunnion carriage No. 54.
26597	12 C 55 T C—L_1 M	24,500	54,500	10.50	11.88		Bright granular	Non-accepts No. 55.
26781	L_2 M, second bar.	31,500	59,000	21.90	29.50		Silky	Accepts trunnion carriage No. 55.
26599	12 C 56 T C—L_1 M	25,250	57,000	20.00	18.82		Bright granular	Non-accepts No. 56.
26782	L_2 M	32,000	61,000	30.20	33.76		Silky	Accepts trunnion carriage No. 56.
27583	12 C 57 T C—L_1 M	36,500	72,500	16.40	19.17		Granular, silky spot on rim.	Accepts trunnion carriage No. 57.

27584	12 C 58 T C—L_1 M	35,500	71,000	12.60	14.83	Granular	Non-accepts trunnion carriage No. 58.
27585	12 C 59 T C—L_1 M	35,500	73,000	14.70	17.02	do	Accepts trunnion carriage No. 59.
27586	12 C 60 T C—L_1 M	40,750	73,000	15.50	15.92	Granular, silky spot on side.	Accepts trunnion carriage No. 60.
27587	12 C 61 T C—L_1 M	35,000	72,000	16.40	19.52	Silky, granular rim	Accepts trunnion carriage No. 61.
27337	12 C 62 T C—L_1 M	43,000	73,000	20.40	21.66	Fine granular	Accepts trunnion carriage No. 62.
27621	12 C 63 T C—L_1 M	33,500	70,500	17.60	18.82	Granular, silky spot on side.	Accepts trunnion carriage No. 63.
26944	12 C 64 T C—L_1 M	36,500	71,000	13.20	16.67	Granular	Non-accepts No. 64.
27219	L_2 M, second bar.	38,000	70,500	16.00	20.22	Granular, silky spot on side.	Accepts trunnion carriage No. 64.
26945	12 C 65 T C—L_1 M	37,000	72,000	11.00	14.13	do	Non-accepts No. 65.
27220	L_2 M, second bar.	40,000	70,000	15.50	19.52	Silky	Accepts trunnion carriage No. 65.
26946	12 C 66 T C—L_1 M	37,000	72,250	13.50	17.71	Silky, granular rim	Non-accepts No. 66.
27221	L_2 M, second bar.	38,750	70,000	15.50	19.17	Granular, silky on side; accordeon stretch.	Accepts trunnion carriage No. 66.
27338	12 C 67 T C—L_1 M	46,000	83,500	17.80	21.66	Granular, silky spot on rim.	Accepts trunnion carriage No. 67.
27339	12 C 68 T C—L_1 M	46,000	82,000	14.40	18.82	Silky, granular rim on one side.	Accepts trunnion carriage No. 68.
27622	12 C 69 T C—L_1 M	44,500	84,500	16.00	19.52	Granular, silky spot on side.	Accepts trunnion carriage No. 69.
27330	12 C 70 T C—L_1 M	44,000	82,000	17.20	18.11	Silky, granular rim	Accepts trunnion carriage No. 70.
27331	12 C 71 T C—L_1 M	50,500	82,500	15.80	17.77	do	Accepts trunnion carriage No. 71.
27332	12 C 72 T C—L_1 M	50,000	86,500	23.50	32.80	Silky, granular specks	Accepts trunnion carriage No. 72.
27653	12 C 74 T C—L_1 M	45,500	73,500	19.50	21.32	Granular, silky spot on side.	Accepts trunnion carriage No. 74, and flanges Nos. 20 and 21 F.
27333	12 C 77 T C—L_1 M	48,500	79,000	17.70	22.71	Granular, earthy	Accepts trunnion carriage No. 77.
27623	12 C 78 T C—L_1 M	39,000	75,000	16.00	19.87	Granular, silky spot on side.	Accepts trunnion carriage No. 78.
27624	12 C 79 T C—L_1 M	39,000	74,500	20.00	25.46	do	Accepts trunnion carriage No. 79.
27588	12 C 80 T C—L_1 M	42,250	75,000	20.20	25.46	Silky, shearing	Accepts trunnion carriage No. 80.
27625	12 C 81 T C—L_1 M	37,000	75,000	18.00	20.62	Silky	Accepts trunnion carriage No. 81.
27589	12 C 82 T C—L_1 M	40,000	73,500	23.20	25.81	do	Accepts trunnion carriage No. 82.
27590	12 C 83 T C—L_1 M	40,000	75,000	17.30	20.97	Granular, silky spot on side.	Accepts trunnion carriage No. 83.
27654	12 C 84 T C—L_1 M	45,500	73,750	20.50	22.36	Earthy, granular specks; accordeon stretch.	Accepts trunnion carriage No. 84.
27655	12 C 85 T C—L_1 M	42,500	72,500	13.50	16.32	Granular, silky spot	Accepts trunnion carriage No. 85.
27656	12 C 88 T C—L_1 M	41,000	72,000	18.50	22.36	Earthy, granular specks	Accepts trunnion carriage No. 88.
27657	12 C 89 T C—L_1 M	40,750	71,500	16.00	20.22	Granular, silky on side	Accepts trunnion carriage No. 89, and brackets Nos. 55, 56, and 57 D.
	Brackets.						
27410	12 C 41 B—L_1 M	42,500	72,100	23.00	30.85	Earthy, granular	Accepts brackets Nos. 39, 40, 41, and 42 B.
	12 C 44 B—L_1 M	40,000	69,500	20.40	24.41	do	Accepts brackets Nos. 43 and 44 B.
27409	12 C 47 B—L_1 M	40,000	72,000	19.60	20.07	do	Accepts brackets Nos. 45, 46, 47, and 48 B.

APPENDIX 33.

PROGRESS REPORT ON MANUFACTURE OF MORTARS AND MORTAR CARRIAGES AT THE BUILDERS' IRON FOUNDRY, PROVIDENCE, R. I., DURING THE FISCAL YEAR ENDED JUNE 30, 1893.

(1 plate.)

NO. 40 CODDING STREET,
Providence, R. I., August 29, 1893.

SIR: I have the honor to submit the following report of the progress of the work under the supervision of the inspector of ordnance at this station for the year ending June 30, 1893:

CAST-IRON BODIES FOR 12-INCH B. L. RIFLED MORTARS, STEEL HOOPED.

The bodies cast at South Boston, Mass., and during the previous year transferred to these works, enabled the Builders' Iron Foundry to proceed with the finishing and assembling of the 12-inch B. L. rifled mortars without the necessity of casting any new ones until December 23, 1892, upon which date the first heat was made. And since that time these heats have been regularly undertaken throughout the year.

Some eleven bodies have been successfully cast, inspected, and accepted; three heats, Nos. 173, 176, and 178, proving failures. The first one was due to not sufficiently heating the metal, a portion of it remaining in the furnace and refusing to run out, while the other two failures were due to the opposite cause, the metal being heated too much and the casting proving too hard was not presented by the company for acceptance.

The results of these different heats is shown in the following table:

Date of casting.	No. of heat.	Weight of casting.	Amount of water raised 60°.	Time in melting and fusion.	Tensile strength.		Initial tension.			Remarks.
					Breech.	Muzzle.	Inner breech.	Outer breech.	Inner muzzle.	
1892.		*Lbs.*	*Gallons.*	*H. M.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
Dec. 23	166	37,735	27,838.63	10 24	30,474	31,853	7,624	2,607	9,865	Assembled in mortar No. 51.
1893.										
Jan. 18	167	37,580	22,829.25	10 27	30,367	32,837	12,115	2,483	10,557	To be assembled.
Feb. 9	168	37,320	24,470.00	10 58	30,834	31,163	6,570	2,483	9,000	Assembled in mortar No. 54.
Feb. 24	169	37,500	24,487.50	13 16	31,104	32,963	7,477	2,700	7,719	Assembled in mortar No. 55.
Mar. 14	170	37,050	26,820.00	10 08	34,966	32,133	9,519	4,733	13,119	To be assembled.
Mar. 22	171	36,450	22,023.00	11 19	32,320	33,190	4,073	310	13,708	Assembled in mortar No. 56.
Mar. 29	172	37,273	22,979.25	11 57	32,021	35,927	7,200	3,166	11,354	Assembled in mortar No. 57.
Apr. 5	173	.....	.....	.....	.....	.....	.....	.....	.....	Not presented; broken up.
Apr. 13	174	36,603	26,596.00	13 00	30,319	33,790	6,732	5,724	12,456	Assembled in mortar No. 58.
Apr. 20	175	36,800	26,680.50	11 53	29,814	32,867	7,788	3,259	10,904	To be assembled.
Apr. 27	176	37,150	23,408.00	10 17	.....	.....	.....	.....	.....	Not presented; too hard.
May 3	177	36,762	25,590.00	10 31	29,951	29,493	6,577	2,017	11,423	To be assembled.
May 9	178	36,800	22,533.50	12 14	.....	.....	.....	.....	.....	Not presented: too hard.
June 16	179	36,500	23,739.50	9 37	33,990	34,383	7,719	2,250	14,455	To be assembled.

The mode of casting these bodies has been fully described by my predecessors. A graphic illustration is presented in Pl. I, which shows the method of conveying the metal to the pit and the overflow bed for the surplus metal.

The operations observed in the fabrication of one of these bodies are as follows:

1. Molding body.
2. Making core.
3. Baking core.
4. Assembling mold in pit.
5. Piping of core.
6. Preparing air furnace.
7. Charging furnace.
8. Lighting fire.
9. Noting time of melting.
10. Casting and testing points.
11. Noting time in fusion.
12. Tapping of furnace.
13. Noting time of casting.
14. Cooling of casting through arbor.
15. Removing arbor.
16. Cooling through interior.
17. Stripping of rough body.
18. Removing rough body from pit.
19. Measuring length of rough body.
20. Weight of rough body.
21. Rough body in heading lathe.
22. Rough body in boring lathe.
23. Cutting breech disk.
24. Cutting out initial tension ring, breech.
25. Cutting out initial ring, muzzle.
26. Weight of sinking head above muzzle disk.
27. Laying out specimens from breech disk.
28. Laying out specimens from muzzle disk.
29. Measuring tension ring, muzzle.
30. Measuring tension ring, breech, small.
31. Measuring tension ring, breech, large.
32. Preparing specimens for test at Watertown Arsenal.
33. Inspection of finished body.

Detailed reports have been forwarded to the Ordnance Office after the inspection of each body.

FINISHING AND ASSEMBLING 12-INCH B. L. RIFLED MORTARS.

During the year twenty-two of these mortars have been finished, inspected, accepted and shipped to Sandy Hook Proving Ground. The work has progressed uniformly and acceptably, the class of work turned out being up to the high standard established by the Department.

The method of assembling and finishing these mortars, has been fully described in the report of the Chief of Ordnance for the year 1892. In Pl. II are represented four of these mortars, showing the breech mechanism in various positions. In the first one it is entirely opened, ready for loading; in the second it is only partly opened; in the third it is shut, and in the fourth it is locked, ready for firing.

The different operations to be observed in the finishing and assembling of these mortars are as follows:

1. Boring set of A hoops
2. Facing set of A hoops.
3. Measuring set of A hoops.
4. Preparation of body for shrinkage surfaces of A hoops.
5. Testing eccentricity of bore.
6. Calipering shrinkage surface of body for A hoops.
7. Star gauging original bore.
8. Shrinking on of five A hoops.
9. Star gauging after A hoops.
10. Measuring expansion of A hoops.
11. Boring set of B hoops.
12. Facing set of B hoops.
13. Measuring set of B hoops.
14. Turning exterior of assembled A hoops for shrinkage surface of B hoops.
15. Calipering shrinkage surface of A hoops.
16. Shrinking on of six B hoops.
17. Star gauging after B hoops.
18. Measuring expansion of B hoops.
19. Turning exterior of assembled B hoops and cast-iron chase.
20. Measuring muzzle of cast-iron chase before rounding off.
21. Finishing 12-inch bore.
22. Finishing powder chamber.
23. Star-gauging 12-inch bore.
24. Star-gauging powder chamber.
25. Rifling mortar.
26. Star-gauging rifling.
27. Cutting and slotting screw in breech recess.
28. Measuring top and bottom of threads in breech recess before rounding off.
29. Milling seat for hinge block.
30. Milling seat for segment.
31. Fitting segment.
32. Fitting hinge block.
33. Reaming conical bore.
34. Star-gauging conical bore.
35. Making breechblock.
36. Calipering breechblock.
37. Casting tray.
38. Preparing specimens.
39. Testing specimens.
40. Finishing spindle.
41. Finishing face plate.
42. Finishing translating roller.
43. Finishing gas-check cups.
44. Finishing pinion.
45. Assembling breech mechanism.
46. Finishing breech recess, 15.0200.
47. Finishing trunnion hoop.
48. Final inspection of mortar.
49. Preponderance of mortar.
50. Weight of mortar.
51. Marking muzzle of mortar.
52. Marking console of mortar.
53. Marking segment of mortar.
54. Painting mortar.
55. Boxing breech mechanism of mortar.
56. Slushing breech mechanism and bore of mortar.
57. Placing wood tompions in breech and muzzle of mortar.
58. Wood protector for arc segment.
59. Wood protector for seat for hinge block.
60. Wood taps in face of breech.

Detailed reports have been sent to the Ordnance Office after the finish inspection of each mortar.

In the Table A, appended, is a duplicate of the detailed report sent upon the completion of mortar No. 52.

SPRING-RETURN 12-INCH MORTAR CARRIAGE.

This carriage is a combination of an English (Easton and Anderson) and a Russian (Raskazoff) invention, its principal features being the arrangement of spring and hydraulic cylinders to take the recoil.

The lower carriage is made up of two gun-iron rings placed one upon the other, and separated by a live roller ring of steel and wrought iron. The upper carriage consists of a transom and two side frames, containing the necessary mechanism for carrying the mortar, and permanently attached to the upper ring of the lower carriage.

The lower ring, termed the lower base ring, is permanently attached to the masonry by the holding-down bolts, while the upper ring, known as the upper base ring, freely revolves upon it by means of the intervening live roller ring.

The mortar is mounted on two cast-steel trunnion carriages, sliding in the two side frames; to each of these trunnion carriages is attached a piston rod working in a cast-steel cylinder permanently attached to the side frame. At the same time the trunnion carriages are connected by means of the compression screw with the nest of springs contained in the spring cylinders, the upper section of which are cast into and form part of the side frames.

These spring and hydraulic cylinders are inclined to the horizon at an angle of 50 degrees, and the mortar is arranged to fire only between angles of 35 and 60 degrees, so that the force of the recoil can be directly taken up by these cylinders and but little lateral strain communicated to the upper base ring. After the recoil the elastic force of the springs will usually return the mortar to battery. Should this fail, hand bars, working in ratchets cut into the side frame, will readily accomplish the result.

The lower base ring is cast from gun iron in a single piece and weighs over 8 tons; it is 14 feet in diameter, having on the lower sides an inner and outer set of holes to receive the holding-down bolts embedded in the masonry. The upper side has a groove cast into it, to serve as a guide for the flange of the conical rollers in the live roller ring. On the interior of this ring is a training gear of gun iron, made in six sections and bolted to the ring.

The live roller ring consists of an inner and an outer hoop of rolled iron and twenty-four steel conical rollers. Each hoop is divided into two sections of 180 degrees each, and they are kept apart by twelve separators, made of cast iron, having a $1\frac{1}{8}$-inch bolt clamping them. These hoops are cut out to fit over the trunnion of the steel conical rollers. To protect these rollers from dust there is attached a guard plate of wrought iron screwed to the upper base ring, the whole, when bound together, readily revolving upon the path cast in the upper face of the lower base ring.

The upper base ring overhangs the lower one for a depth of 3 inches in such a way as to leave a one-sixteenth play between them. It is cast from gun iron in a single piece, is nearly 14 feet in diameter, and weighs about 12 tons. On the under side it has paths or grooves cast into it to fit over the conical rollers of the live roller ring. On the upper side, on a projecting flange, the cast-iron floor plate is screwed; and immediately in rear, fastened in the same way, are the two cast-iron guides as a track for the shot barrow, while in rear of these is screwed the training index finger, graduated to minutes. There is also bolted to the upper base ring the right hand and the left hand side

frames for carrying the mortar; these strengthened and held apart by the transom, which is bolted to them and to the upper base ring.

The vertical tramng shaft of forged steel, having at its lower extremity the training pinion of bronze, which works into the internal training gear, has at the upper end the training worm gear, which works into the worm on the horizontal training shaft.

The right-hand frame of upper carriage is cast from gun iron, and weighs 3 tons; screwed to it on its inclined face are three steps of wrought iron, while to its side is bolted a gun-iron mortar guide for directing the mortar into position, so as to protect the hydraulic cylinders. Cast into the frame and a part of it is the spring cylinder for holding the springs; to extend this cylinder below the side frame an additional casting is bolted to the upper section; while for the purpose of closing the upper end there is bolted to it a gun-iron cap.

Passing through both side frames is the horizontal training shaft of forged steel. On the right-hand side frame are bolted the outer and the inner cast-iron brackets, bushed with bronze, through which this shaft works. On the left-hand side frame there is but one (an outer) bracket for the shaft to work through. This shaft has on it between the two side frames the training worm, working in the worm gear on the horizontal training shaft. At each end of the horizontal training shaft is a training shaft crank, having the handle covered with bronze tubing, and the carriage is so made that one man at each handle readily revolves the upper base ring with its load.

The left-hand side frame is similar to the right-hand one with the exception noted above, and has in addition attached to it the loading mechanism. This last consists of the forged steel loading arm terminating at one end with the loading scoop, made of wrought iron and lined with hard-wood strips. For regulating its height there is a stud and check nut of forged steel. To the other end of the loading arm is attached the forged steel lever loading arm, forked at its extremity, to receive the bronze swivel nut through which works the threaded portion of the forged steel loading screw. At the front end of the side frame is the bronze swivel bearing through which the loading screw works, the bracket for which is bolted to the side frame. At the front end of the loading screw is attached the cast-iron wheel, which has a forged-iron handle cased with bronze tubing.

Connecting and stiffening the two side frames is the gun-iron transom, weighing one and a quarter tons. For a rest for the muzzle of the mortar when in a loading position there is attached to the transom a buffer made up of ten pieces of three-eighths thick felt and two pieces of sheet iron for separators, all surrounded by a sheet-iron protector. The transom also has a buffer stop of hard wood to check the breech of the mortar when the piece is elevated to its highest firing position.

To hold and carry the mortar there are two trunnion carriages of cast steel, weighing nearly a ton each. These work on tongues cast on the side frame, the friction sides of which have bronze gibs riveted to and screwed onto them, while the circular portion in which the trunnion of the mortar rests is also lined with bronze. After the mortar is placed in the carriage a set of buffer felts with separators is placed on the upper side of each trunnion, to act as a cushion when the mortar is returned to battery. On top of these buffers is placed the cast-iron trunnion seat cap, and to hold them in position there is bolted over all the cast-iron holding-down cap. For the purpose of lubricating, two oil holes are placed in each carriage, these holes being protected by covers fitted to them. On the lug on this carriage is attached the

spring compression screws which rest on the springs in the cylinder, separated from them by a hardened steel washer to take up the wear.

The two hydraulic cylinders are made of cast steel and are tested to resist a pressure of 8,000 pounds; one is bolted to each side frame and also to the lower section of the spring cylinder. These have forged steel piston rods attached to the trunnion carriages at one end and working in the cylinder at the other. The two cylinders are connected with each other by means of pipes to correct any inequality of pressure, and they are also arranged to permit the flow of the liquid from the rear to the front of the piston heads, which flow can be regulated by means of the plugs.

For the purpose of inserting the springs in the cylinders there is furnished with each carriage one inserting spring bolt of forged steel 16 feet long.

For elevating and depressing the mortar there is shrunk on it just in front of the trunnion hoop the steel mortar band. To this is bolted two wrought-iron elevating gear brackets, to each of which are attached a bronze elevating gear. These gears work in the forged steel pinions attached to the bronze gear wheel, which in turn works in the forged steel pinions of the hand wheels. These hand wheels have a cast-iron hub with wrought-iron rims and spokes, these spokes extending through the rim to serve as handles. At the end of the shaft on which the hand wheel works is the forged iron clamping nut, which rigidly holds the piece in any position desired, and an index finger extends over the bronze gear wheel to serve as a guide in elevating the mortar.

Outside of the upper base ring and on line with its upper surface there is permanently attached to the masonry the cast-iron index ring divided into half degrees. This is made of cast iron and cast into arcs of 45 degrees for convenience of handling, as the complete circle weighs two tons.

Furnished with each carriage is a pair of shot tongs and a shot truck of forged iron and steel, made to carry either the 600, 800, or 1,000 pound shot. This truck is so arranged that by running it on the upper base ring the loading scoop readily picks up the projectile and carries it to the breech of the mortar.

During the year ten of these carriages have been finished, inspected, and accepted, and shipped. Of this number three were manufactured at Alliance, Ohio, by the Morgan Engineering Company, working as agents for the Builders' Iron Foundry. This work was thus divided to hasten the manufacture.

An illustration of one of these carriages with the mortar mounted is shown in Pl. III. Detailed reports of the physical tests have been sent to the Ordnance Office upon completion of each carriage. In appended Table B is a copy of the one sent with carriage No. 10.

The nomenclature and bill of material of the various parts of this carriage is shown in the following table:

Nomenclature and bill of material of spring-return mortar carriage.

LOWER BASE RING.

No. of parts in carriage.	Name of parts.	Dimensions.				Material.	Weight.	Remarks.
		Length.	Width.	Thickness.	Diameter.			
		Inches.	*Inches.*	*Inches.*	*Inches.*		*Pounds.*	
1	Lower base ring	.....	19½	23½	168	Gun iron	16,500	
1	Internal training gear (6 sections)	.....	8¼	2 3/16	120	....do	1,850	Arcs of 60°.
48	Internal training gear bolts	2¼	.....	.....	¾	Forged iron	25	

LIVE ROLLER RING.

1	Inner hoop (2 sections)	.....	5	1	125 7/8	Rolled iron	1,400	Arcs of 180°.
1	Outer hoop (2 sections)	.....	5	1	154¼	....do		
12	Separators	13⅛	5	4½	.....	Cast iron	312	
12	Separator bolts	16¼	.....	.....	1⅛	Forged iron	60	Through.
4	Roller-ring butt straps	5½	5	1	.....	....do	24	
8	Roller-ring bolts	3⅞	.....	.....	1	....do	11	
8	Roller-ring rivets	3	.....	.....	1	....do	8	
1	Dust guard (4 sections)	.....	11¾	3/16	126	Rolled iron	232	Arcs of 90°.
40	Dust-guard screws	1	.....	.....	½	Forged iron	8	Round head.
16	Dust-guard bolts	¾	.....	.....	⅝	....do	3	With nuts.
24	Conical rollers	15¼	.....	.....	8¾ by 9¾	Forged steel	3,840	

UPPER BASE RING (REVOLVING).

1	Upper base ring (revolving)	.....	19½	23½	168	Gun iron	25,000	
16	Core-hole covers	⅞	.....	.....	5⅞	Cast iron	80	
16	Core-hole calks	.....	.....	.....	.....	Lead	50	
1	Floor plate	65½	31¼	3½	.....	Cast iron	350	
9	Floor-plate screws	1½	.....	.....	½	Forged iron	2	Countersunk.
1	Vertical training shaft	69	.....	.....	3	Forged steel	119	
1	Vertical training shaft nut	1½	.....	.....	1½	....do	2	
1	Vertical training shaft washer	.....	.....	¼	4	....do	1	
1	Vertical training shaft bracket	23¾	15	5¼	.....	Cast iron	176	
1	Vertical training shaft bracket bushing	6	.....	.....	3¾	Bronze	12	
6	Vertical training shaft bracket bushing bolts	4	.....	.....	1¼	Forged iron	12	
1	Training pinion	.....	.....	6	14 1/10	Bronze	170	
1	Training pinion key	5¾	11/16	11/32	.....	Forged iron	1	
1	Training worm gear	.....	.....	4¼	17	Bronze	160	
1	Training worm gear key	4¼	11/16	11/16	.....	Forged steel	2	
2	Guides for shot barrow	23¼	2½	1	.....	Cast iron	20	
10	Guide for shot barrow, screws for	1½	.....	.....	⅝	Steel	2	Countersunk.
1	Training index finger	6¾	3	⅛	.....	Bronze	3	
4	Training index finger screws	¾	.....	.....	⅜	Steel	1	Countersunk.

Nomenclature and bill of material of spring-return mortar carriage—Continued.

RIGHT-HAND FRAME OF UPPER CARRIAGE.

No. of parts in carriage.	Name of parts.	Dimensions.				Material.	Weight.	Remarks.
		Length.	Width.	Thickness.	Diameter.			
		Inches.	*Inches.*	*Inches.*	*Inches.*		*Pounds.*	
1	Right-hand frame of upper carriage	132½	82	20½	.....	Gun iron	5,900	
18	Right-hand frame bolts	5½	.....	.....	1¼	Forged iron	54	Through.
1	Right-hand frame bolt	3½	.....	.....	1½	....do	3	Do.
2	Right-hand frame bolts	7	.....	.....	1¼	....do	8	Tap.
3	Right-hand frame steps	11½	6	⅜	.....	....do	27	
12	Right-hand frame step screws	1½	.....	.....	⅝	....do	3	Countersunk.
1	Right-hand frame buffer	6¼	3	⅛	.....	Sheet iron	7	Filled with 9 sheets of felt and 2 separators.
1	Right-hand frame buffer head plate	6¼	3	⅛	.....	....do	3	
2	Right-hand frame buffer separators	6¼	3	⅛	.....	....do	6	3 layers of felt between each separator.
2	Right-hand frame buffer bolts	5¼	.....	.....	¾	Forged iron	2	Countersunk.
1	Mortar guide	33	11⅝	6	.....	Gun iron	175	
2	Mortar guide bolts	10¾	.....	.....	1½	Forged iron	14	Through.
1	Spring cylinder cap	19	14½	9	.....	Gun iron	83	
2	Spring cylinder cap bolts	5¾	.....	.....	1½	Forged iron	6	Stud.
1	Outer right-hand bracket for horizontal training shaft	19	.....	.....	13¾	Cast iron	95	
3	Outer right-hand bracket bolts	5⅞	.....	.....	1¼	Wrought iron	9	Through tap.
3	Outer right-hand bracket bolts	2½	.....	.....	1¼	....do	5	
2	Outer right-hand bracket bushings	4¾	.....	.....	3⅝	Bronze	6	One has shoulder.
1	Inner right-hand bracket for horizontal training shaft	4½	.....	.....	.....	Cast iron	30	
5	Inner right-hand bracket bolts	2½	.....	.....	⅞	Forged iron	5	
1	Inner right-hand bracket bushings	4¾	.....	.....	2⅝	Bronze	9	
1	Horizontal training shaft	110	.....	2	2	Forged steel	100	
1	Horizontal training shaft worm	8	.....	.....	6	....do	38	Double left-hand thread.
1	Horizontal training shaft worm key	8 1/16	7/16	7/16	.....	....do	1	
1	Horizontal training shaft worm pin	4½	.....	.....	⅜	....do		
1	Worm-gear bracket	25½	.....	10½	18¾	Cast iron	325	
1	Cover to worm-gear bracket	.....	.....	.....	19½	....do	42	
6	Cover to worm-gear bracket, screws for	1¼	.....	.....	⅜	Forged iron	1	Tap.
1	Training crank	15	.....	.....	.....	....do	18	
1	Training-crank handle cover	18	.....	.....	1⅜	Bronze	3	Tubing.
1	Cotter for handle	3¼	.....	1¼	.....	Forged iron	2	
1	Cotter chain and staple	9	.....	.....	.....	....do		Brass chain.

STATIONARY INDEX RING.

1	Stationary index ring (8 sections)	.....	12	7¼	190½	Cast iron	4,000	Arcs of 45°.
16	Stationary index ring bolts	4	1¼	.....	1¼	Forged iron	45	Through.

LEFT-HAND FRAME OF UPPER CARRIAGE.

1	Left-hand frame of upper carriage	132½	82	20½	.....	Gun iron	5,900	
18	Left-hand frame bolts	5½	.....	.....	1¼	Forged iron	54	Through.
1	Left-hand frame bolt	3½	.....	.....	1¼	.....do	3	Do.
2	Left-hand frame bolts	7	.....	.....	1¼	.....do	8	Tap.
3	Left-hand frame steps	11½	6	⅜	.....	.....do	27	
12	Left-hand frame step screws	1½	.....	.....	⅝	Forged steel	3	Countersunk.
1	Left-hand frame buffer	6¼	3	⅜	.....	Sheet iron	7	Filled with 9 sheets of felt and 2 separators.
1	Left-hand frame buffer head plate	6½	3	⅜	.....	.....do	3	
2	Left-hand frame buffer separators	6¼	3	⅛	.....	.....do	6	3 layers of ⅛ felt between each separator.
2	Left-hand frame buffer bolts	5¼	.....	.....	¾	Forged iron	2	Countersunk.
1	Mortar guide	33	11⅝	6	.....	Gun iron	175	
2	Mortar-guide bolts	10¾	.....	.....	1½	Forged iron	14	Through.
1	Spring cylinder cap	19	14½	9	.....	Gun iron	83	
2	Spring cylinder cap bolts	5¾	.....	.....	1½	Forged iron	6	Stud.
1	Left-hand frame bracket for horizontal training shaft	12	.....	.....	14	Cast iron	90	
6	Left-hand frame horizontal training shaft bolts	4¾	.....	.....	1¾	Forged iron	18	Through.
1	Left-hand frame bracket bushing	4	.....	.....	3⅝	Bronze	6	
1	Training crank	15	.....	.....	.....	Forged iron	18	Center to center.
1	Training crank handle cover	18	.....	.....	1⅜	Bronze	3	Tubing.
1	Cotter for handle	3¼	.....	1¼	.....	Forged iron	2	Brass chain.
1	Cotter chain and staple	9	.....	.....	.....	.....do		
1	Loading arm	44	.....	.....	3½ to 2⅓	.....do	98	
1	Loading arm shaft	21½	.....	.....	3½	.....do	46	
1	Loading arm shaft key	4	11/16	13/32	.....	Steel	2	
1	Loading arm shaft key pin	4	.....	.....	¾	.....do	1	
1	Scoop stud and check nut	9⅛	.....	.....	2¼	Forged steel	3	
1	Loading arm flange	13½	8¼	5	.....	Cast steel	66	
1	Loading arm scoop	.....	16¼	¼	16½	Wrought iron		
2	Loading arm linings	10¾	4	1⅜	.....	Wood, hard	4	
8	Loading arm lining rivets	2	.....	.....	⅝	Forged iron	1	For wood.
8	Loading arm lining screws	2	.....	.....	⅝	Forged steel		
1	Lever loading arm with yoke	22½	1	5½	.....	.....do	101	Forked.
1	Lever loading arm swivel nut	6	.....	.....	6	Bronze	19	
1	Lever loading arm collar screw	1½	.....	.....	3½	Forged steel	1	
1	Lever loading arm collar pin	3½	.....	.....	⅝	.....do	1	Taper.
1	Lever loading arm washer	.....	.....	¼	4	.....do	1	
1	Lever loading arm washer nut	.....	.....	1½	2¾	.....do	2	
2	Loading screw swivel studs	2¼	.....	.....	⅝	Forged iron	1	
2	Loading screw swivel nuts	1⅜	½	.....	.....	.....do	1	Hexagonal.
1	Swivel bearing for loading	9¼	.....	.....	7½	Bronze	32	Includes also the cap.
1	Hand-wheel for loading	.....	.....	2	29½	Cast iron	90	
1	Hand-wheel handle	16½	.....	.....	1⅜	Forged iron	5	
1	Hand-wheel handle nut	.....	.....	¾	1⅜	.....do	1	Hexagonal.
1	Hand-wheel handle casing	12	.....	.....	1 5/16	Bronze	3	Tubing.
1	Bracket for swivel bearing	12¾	6⅛	5¼	.....	Cast iron	20	
4	Bracket for swivel-bearing bolts	2½	.....	.....	⅞	Forged iron	4	Tap.
1	Loading screw	114¼	.....	.....	2	Forged steel	135	Loading hand-wheel at end.

Nomenclature and bill of material of spring-return mortar carriage—Continued.

TRUNNIONS, RIGHT AND LEFT.

No. of parts in carriage.	Name of parts.	Dimensions.				Material.	Weight.	Remarks.
		Length.	Width.	Thickness.	Diameter.			
		Inches.	*Inches.*	*Inches.*	*Inches.*		*Pounds.*	
2	Trunnion carriages	38½	19¼	19	.....	Cast steel	1,850	Right and left.
8	Trunnion-carriage gibs	37¼	2	1½	.....	Bronze	96	
24	Trunnion-carriage gib screws	1½	.....	.....	½	Brass	2	Countersunk.
24	Trunnion-carriage gib rivets	1½	.....	.....	½	do	2	Countersunk both ends.
2	Trunnion seat linings	.....	6	½ to ¾	13½	Bronze	36	
2	Trunnion seat lining dowels	2	.....	.....	¼	do	1	
2	Trunnion seat caps	13½	6	7	12	Cast-iron	129	
30	Trunnion felts	12⅞	5⅞	⅜	.....	.....	15	
10	Trunnion felt separators	12⅞	5⅞	⅛	.....	Rolled iron	30	
2	Holding-down caps	13½	11⅝	6	.....	Cast-iron	242	
2	Holding-down cap bolts	20¾	.....	.....	1¾	Forged iron	19	Through with nut.
4	Oil-well covers	3¼	2	¼	.....	Bronze	4	
4	Oil-well cover thumbscrews	¾	.....	.....	¼	Steel	1	
8	Bolts for brackets for elevating mechanism	4¾	.....	.....	1	Forged steel	24	Stud.
8	do	4	.....	.....	1	do	24	Do.
4	Taper keys for bracket for elevating mechanism	11	1⅜	⅝	.....	do	8	Right and left handed ⅛-inch taper per foot.
2	Spring compression screws	16¼	.....	.....	3¼	do	76	
2	Spring compression screw check nuts	4 17/32	1½	.....	3¼	do		
2	Spring compression screw washers	.....	.....	1⅜	3⅜ to 1⅝	do	4	Hardened.
1	Inserting spring bolt	192	.....	.....	1¾	do	155	Nut at each end.
1	Inserting spring-bolt washer, large	.....	.....	1 13/16	9½	Cast-iron	25	
1	Inserting spring-bolt washer, small	.....	.....	1⅜	4 9/16	do	10	

TRANSOM FOR UPPER CARRIAGE.

1	Transom for upper carriage	65	55	9	.....	Gun iron	2,425	
6	Transom bolts	4	.....	.....	1¼	Forged iron	18	Tap.
2	do	4	.....	.....	1¼	do	18	Stud.
1	Transom buffer	10	6	5⅞	.....	⅜ forged iron	15	Filled with 10 pieces ⅜-inch felt and 2 separators.
2	Transom felt separators	7½	5⅜	⅛	.....	Sheet iron	6	3 pieces of felt between each separator.
1	Transom buffer bolt	7	.....	.....	¾	Forged iron	6	Through.
1	Transom buffer stop	20	.....	.....	5	Wood, hickory	10	

SPRING CYLINDERS (LOWER SECTION).

2	Spring cylinders	60⅛	.....	.....	12¼	Gun iron	2,100	Suspended to S. F.
4	Spring cylinder bolts, long	5	.....	.....	1½	Forged iron	12	Through turned.
14	Spring cylinder bolts, short	5½	.....	.....	1¼	....do	42	Do.
4	Spring cylinder bolts, medium	5¼	.....	.....	1¼	....do	11	Stud.
1	Ratchet wrench	.....	.....	.....	.....	Malleable iron	15	No. 3, old style, Bridge Lowell Wrench Company.

HYDRAULIC CYLINDERS.

2	Hydraulic cylinders	52 1/16	.....	.....	10	Cast steel	2,100	Right and left.
2	Hydraulic cylinder piston rods	96¼	.....	.....	3 7/16	Forged steel	202	
2	Hydraulic cylinder piston-rod keys	13⅜	11⅜	6	.....	....do	30	
2	Hydraulic cylinder piston-rod bushings	7½	.....	.....	7½	Bronze	90	Shrunk on piston.
2	Hydraulic cylinder piston-rod heads	11 13/16	.....	.....	9	....do	25	
4	Hydraulic cylinder piston-rod stuffing box glands	.....	3½	.....	5	....do	62	
2	Hydraulic cylinder piston-rod stuffing boxes	12	.....	.....	8	....do	175	
2	Hydraulic cylinder piston-rod bushings for stuffing-box glands.	.....	1½	.....	3⅜	....do	7	
4	Hydraulic cylinder piston-rod rings	1¼	.....	.....	4¾	....do	12	
16	Hydraulic by-pass plugs	1	.....	.....	1¼	....do	10	
4	Hydraulic finger plugs	4 1/16	.....	.....	1¼	....do	6	
4	Hydraulic pipe plugs, large	1½	.....	.....	2¼	....do	14	
2	Hydraulic pipe plugs, small	1¼	.....	.....	1¾	....do	2	
4	Hydraulic cylinder bolts	10¼	.....	.....	1½	Forged iron	28	Through turned.
4	....do	5	.....	.....	1½	....do	12	
2	Hydraulic cylinder draining pipes, vertical	10	.....	.....	1¼	Hydraulic pipe	3	
2	Hydraulic cylinder draining pipes, horizontal	40	.....	.....	1	....do	15	
2	Hydraulic flanged couplings	.....	.....	2⅛	7	Bronze	24	
1	Hydraulic angle coupling	5¾	4⅝	2½	.....	....do	7	
6	Hydraulic coupling bolts	3	.....	.....	¾	Iron	6	
6	Hydraulic coupling nuts	.....	.....	.....	¾	Forged iron	5	
2	Hydraulic coupling washers	.....	.....	¼	2½	Leather	1	
1	Hydraulic hanger rod	35½	.....	.....	⅝	Forged iron	3	With three check nuts.

Nomenclature and bill of material of spring-return mortar carriage—Continued.

ELEVATING MECHANISM.

No. of parts in carriage.	Name of parts.	Dimensions.				Material.	Weight.	Remarks.
		Length.	Width.	Thickness.	Diameter.			
		Inches.	*Inches.*	*Inches.*	*Inches.*		*Pounds.*	
2	Elevating mechanism brackets	$23\frac{3}{4}$	$21\frac{3}{4}$	$6\frac{1}{2}$	.....	Cast steel	450	
2	Elevating mechanism bracket set screws	$1\frac{1}{2}$	.....	.....	$\frac{7}{16}$	Forged steel	1	
4	Elevating mechanism bushings	$4\frac{1}{4}$	.....	.....	$2\frac{3}{4}$	Bronze	25	
2	Elevating hand-wheel shafts	$26\frac{7}{8}$	.....	.....	$1\frac{5}{8}$	Forged steel	40	Taps into bracket at one end.
2	Elevating hand-wheel shaft nuts	.....	.....	.....	.....	....do		
2	Elevating hand-wheel shaft-clamping nuts	$13\frac{1}{4}$	.....	.....	.....	Forged iron		
2	Elevating hand-wheel shaft-clamping nut washers	.....	.....	$\frac{1}{4}$	3	Bronze		
2	Elevating hand-wheel pinions	$6\frac{1}{2}$	.....	.....	$5\frac{3}{4}$	Forged steel	138	
2	Elevating hand-wheel pinion keys	$3\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	.....	....do		
2	Elevating hand-wheel hubs	.....	.....	$\frac{3}{4}$	7	Cast iron		
2	Elevating hand-wheel rims	.....	.....	.....	24	Wrought iron		
12	Elevating hand-wheel spokes	$14\frac{7}{8}$	.....	.....	1	....do		
2	Elevating pinion shafts	$29\frac{1}{2}$	.....	.....	$2\frac{1}{8}$	Forged steel	88	Pin on one end, nut at other.
2	Elevating pinion-shaft washers	.....	.....	$\frac{1}{4}$	$2\frac{1}{2}$	....do		
2	Elevating pinion-shaft pins	$2\frac{1}{2}$	.....	$\frac{1}{2}$	.....	....do		
2	Elevating pinion-shaft gear wheels	.....	$2\frac{1}{2}$	.....	20	Bronze	164	48 teeth.
2	Elevating pinion-shaft gear-wheel keys	$2\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{32}$	.....	Forged steel	2	
2	Collar nuts	.....	.....	$1\frac{1}{4}$	$2\frac{1}{2}$	Forged iron		
2	Elevating index fingers	8	4	$\frac{1}{4}$	.....	Bronze	6	
4	Elevating index-finger screws	$\frac{3}{4}$	.....	.....	$\frac{3}{8}$	....do	1	Round head.
1	Mortar band	.....	.....	.....	35	Forged steel	180	
6	Mortar band bolts	$2\frac{3}{4}$	.....	.....	$\frac{3}{4}$	Forged iron	6	Tap, 4 reamed.
2	Mortar band elevating gears	$43\frac{1}{2}$	5	2	.....	Bronze	154	
2	Mortar band elevating gear brackets	$11\frac{1}{2}$	9	$\frac{3}{4}$	.....	Forged iron	49	
6	Mortar band elevating gear-bracket bolts, large	3	.....	.....	$\frac{5}{8}$	....do	3	Through.
6	Mortar band elevating gear-bracket bolts, small	$2\frac{1}{2}$	.....	.....	$\frac{5}{8}$	....do	3	Tap.
1	Shot truck complete	$29\frac{1}{2}$	.....	.....	.....	....do	252	
1	Shot truck tongs	$25\frac{5}{8}$	$2\frac{1}{4}$	$\frac{7}{8}$	.....	....do	27	

HOTCHKISS ORDNANCE COMPANY—SHRAPNEL FOR 3.2-INCH GUN AND 12-POUNDER COMMON SHELL.

In addition to the above work on mortars and carriages, the officer stationed here has also been called upon to inspect 1,000 shrapnel for 3.2-inch gun and 500 12-pounder common shell, manufactured by the Hotchkiss Ordnance Company, at their works in Providence. All of these have been accepted and shipped as per instructions.

Very respectfully, your obedient servant,

M. W. LYON,
Captain, Ord. Dept., U. S. Army, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

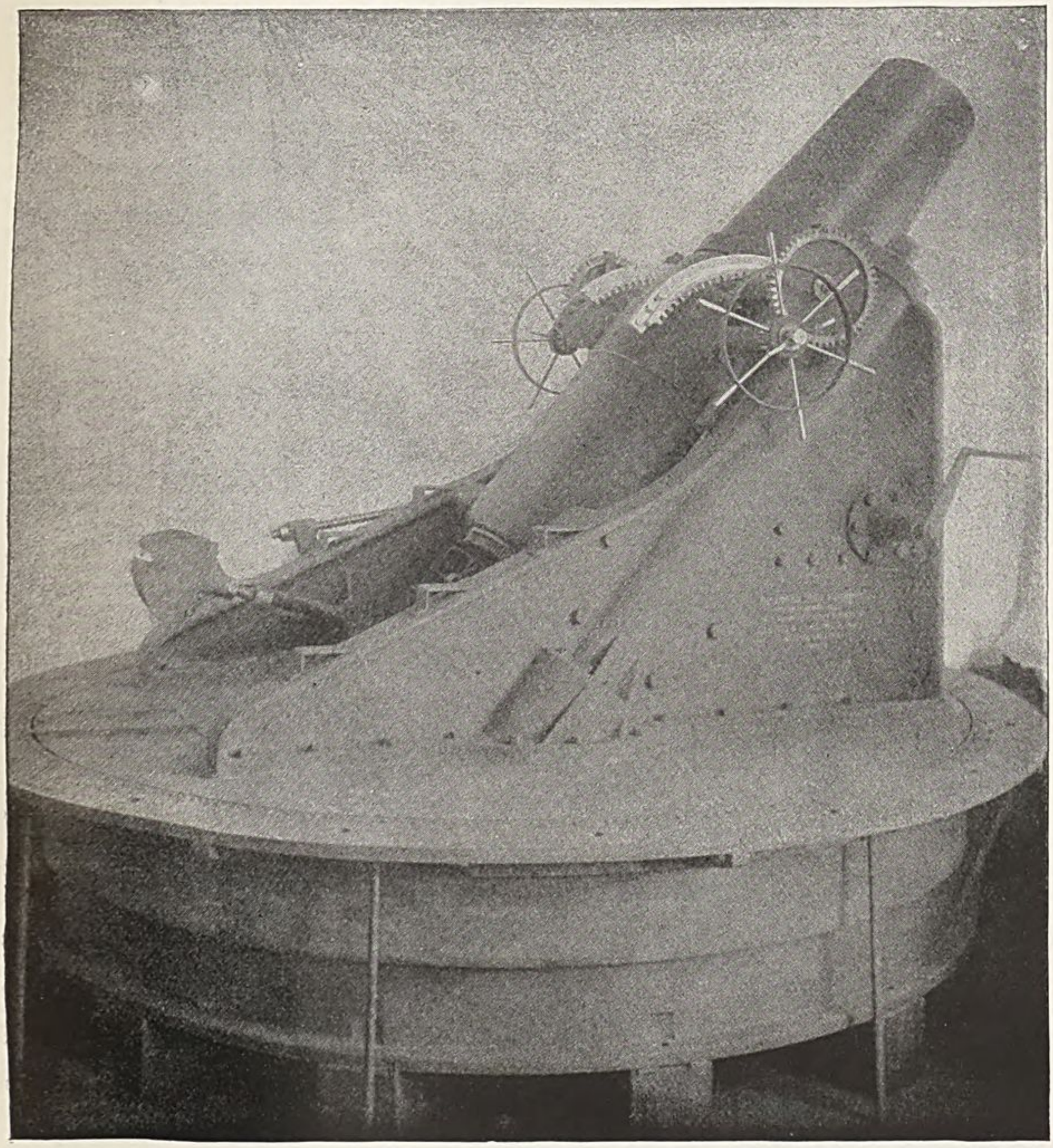
(4809–'93.)

TABLE B.—*Consolidated report of physical tests made at Providence, R. I., for spring-return carriage No. 10, for 12-inch B. L. rifled mortar, manufactured by Builders' Iron Foundry, under contract with the United States dated February 20, 1893.*

Name of part.	Material.	Tabular No.	Position of specimen.	Tenacity.	Elongation.	Material made at—
				Pounds.	*Inches.*	
Lower base ring	Gun iron	2	Coupon	28,533		Providence, R. I.
Training gear	do	2	Representative	28,400		Do.
Live roller ring hoops	Rolled iron		do	55,000	22.50	Boston, Mass.
Separators	Cast iron	1	do	17,400		Providence, R. I.
Conical rollers	Forged steel	3	do	92,250	22.41	Newark, N. J.
Upper base ring	Gun iron	2	Coupon	29,700		Providence, R. I.
Floor plate	Cast iron	1	Representative	17,400		Do.
Vertical training shaft	Forged steel	2	do	77,000	24 0	Newark, N. J.
Vertical training shaft bracket	Cast iron	1	do	17,400		Do.
Training pinion	Bronze	1	Cut from casting	51,000	16.50	Providence, R. I.
Training pinion worm gear	do	1	do	49,200	14.50	Do.
Stationary index	Cast iron	1	Representative	17,400		Do.
Right-hand side frame	Gun iron	2	Cut from casting	28,600		Do.
Mortar guide, right	do	2	Representative	28,600		Do.
Spring cylinder cap, right	do	2	do	28,600		Do.
Brackets, training shaft	Cast iron	1	do	17,400		Do.
Horizontal training shaft	Forged steel	2	do	80,250	27.30	Newark, N. J.
Horizontal training shaft worm	do	2	do	92,250	22.40	Do.
Right-hand spring cylinder	Gun iron	2	Cut from casting	30,800		Providence, R. I.
Worm gear bracket	Cast iron	1	Representative	17,400		Do.
Left-hand side frame	Gun iron	2	Cut from casting	28,100		Do.
Mortar guide, left	do	2	Representative	30,900		Do.
Spring cylinder cap, left	do	2	do	30,900		Do.
Bracket, horizontal training shaft	Cast iron	1	do	17,400		Do.
Loading arm	Forged iron		do	57,500	32 0	Boston, Mass.
Loading arm shaft	Forged steel	2	do	73,500	27.30	Newark, N. J.
Loading arm shaft flange	Cast steel	2	do	72,000	9.0	Do.
Loading screw	Forged steel	2	do	72,500	30.0	Do.
Loading arm with yoke	do	2	Cut from casting	58,000	27.50	Boston, Mass.
Loading arm swivel nut	Bronze	1	Representative	39,800		Providence, R. I.
Swivel bearing for loading	do	1	do	39,800		Do.
Hand wheel	Cast iron	1	do	17,400		Do.
Left-hand spring cylinder	Gun iron	2	Cut from casting	29,250		Do.
Transom	do	2	Representative	28,500		Do.
Left-hand trunnion carriage	Cast steel	1	Cut from casting	65,000	15.9	Newark, N. J.
Right-hand trunnion carriage	do	1	do	66,000	21.5	Do.
Holding-down caps	Cast iron	1	Representative	17,400		Providence, R. I.
Spring compression screw	Forged steel	2	do	73,250	31.0	Newark, N. J.
Hydraulic cylinders	Cast steel	2	do	72,000	15.38	Do.
Piston rods	Forged steel	3	do	87,750	28.77	Do.
Piston-rod stuffing box	Bronze	1	do	39,800		Providence, R. I.

Elevating mechanism brackets	Cast steel	2	Representative	72,000	18.0	Newark, N.J.
Elevating hand-wheel shaft	Forged steel	2	....do	78,000	25.5	Do.
Elevating pinions	....do	2	....do	93,000	22.2	Do.
Elevating pinion shaft gear wheels	Bronze		....do	47,800		Providence, R. I.
Mortar band	Forged steel	2	....do	72,583	33.83	Midvale Steel Works.
Mortar band elevating gear	Bronze	1	Cut from casting	53,500		Providence, R. I.
Mortar band elevating gear bracket	Forged iron		Representative	57,400		Do.

PLATE I.



Appendix 33, 1893.

SPRING RETURN CARRIAGE FOR 12-INCH MORTAR.

APPENDIX 34.

PROGRESS REPORT ON THE MANUFACTURE OF ORDNANCE AT THE WEST POINT FOUNDRY, COLD SPRING, N. Y.

WEST POINT FOUNDRY,
Cold Spring, N. Y., July 21, 1893.

SIR: I have the honor to submit the following report of the operations of the Ordnance Department at this foundry during the fiscal year ended June 30, 1893:

Under contract dated December 5, 1890, for the manufacture of eleven 8-inch B. L. steel rifles, the progress during the year is given by schedule, showing the condition of the work at the beginning and end of the year, as follows:

CONDITION OF THE WORK JUNE 30, 1892.

Gun No. 1. Completed and shipped to Sandy Hook June 6, 1892.
Gun No. 2. Practically finished except fitting breech mechanism.
Gun No. 3. Finished except rifling, finish boring powder chamber, and finishing and fitting breech mechanism.
Gun No. 4. Jacket, C and D hoops assembled.
Gun No. 5. Jacket, C and D hoops assembled.
Gun No. 6. Jacket and C hoops assembled.
Gun No. 7. Jacket and C hoops assembled.
Gun No. 8. Jacket and C hoops assembled.
Gun No. 9. Jacket and C hoops assembled.
Gun No. 10. Jacket ready for assembling.
Gun No. 11. Jacket ready for assembling.
Thirty-two hoops finished ready for assembling.
Progress on breech mechanism in such condition as to be ready for fitting to the guns as soon as they shall be completed up to this stage of the manufacture.

CONDITION OF THE WORK JUNE 30, 1893.

Gun No. 2. Completed and shipped July 27, 1892.
Gun No. 3. Completed and shipped October 6, 1892.
Gun No. 4. Completed and shipped April 17, 1893.
Gun No. 5. Completed and shipped April 17, 1893.
Gun No. 6. Completed; awaiting shipment.
Gun No. 7. Completed except assembling mechanism; mechanism completed.
Gun No. 8. Completed except fitting and assembling breech mechanism; mechanism practically completed.
Gun No. 9. Completed except slotting thread in recess, boring chamber, boring cones, and fitting and assembling mechanism.
Thread cut on breechblock, but not slotted. Tray partly machined; thread cut on roller. Pinion completed and fitted on handle. Rotating ring machined. Face plate partly machined, but not drilled. Spindle, cups, and washers completed.
Gun No. 10. Shrinkages completed; exterior finished, turned, rough bored; bushing inserted, but thread not cut in same.
Thread cut on block, but not slotted. Tray partly machined; thread cut on roller. Pinion and rotating ring machined, not fitted. Face plate planed and rough turned. Spindle, cups, and washers completed.
Gun No. 11. Jacket, C and D hoops shrunk together.
Breechblock rough turned. Tray partly machined; thread cut on roller. Pinion and rotating ring partly machined. Spindle, cups, and washers completed.

The contract, as extended, expires November 1, 1894, but it is expected that the work will be completed about a year in advance of that date.

Work has also been in progress during the year, under contract with the Pneumatic Torpedo and Construction Company, for two pneumatic dynamite gun batteries—one at Sandy Hook, N. J., and one for the defenses of San Francisco.

This contract is dated January 27, 1893, but a considerable portion of the work had already been done under a previous contract, the West Point Foundry Company being subcontractors for the greater part of the work. At the end of the year the condition of the work was as follows:

8-inch pneumatic dynamite gun No. 1. Completed and in possession of the Pneumatic Torpedo and Construction Company before date of contract. To be transferred and mounted at Sandy Hook, N. J.

15-inch pneumatic dynamite gun No. 1. Finished under original contract. Electric motor for maneuvering to be attached.

15-inch pneumatic dynamite gun No. 2. Assembled and mounted on carriage. Electric motor for maneuvering to be attached.

15-inch pneumatic dynamite gun No. 3. About same progress as No. 2.

15-inch pneumatic dynamite gun No. 4. All parts on hand and in progress except training gear and a few smaller parts.

15-inch pneumatic dynamite gun No. 5. Same as No. 4. Boilers in place and foundations in progress for Sandy Hook plant.

Air compressors in progress at Norwalk, Conn.

Firing reservoirs in progress at Thurlow, Pa.

Storage reservoirs in progress at Chester, Pa.

None of these appliances in progress for Pacific coast plant. It is the intention of the company to have such work done in San Francisco.

The West Point Foundry Company are also contractors for the manufacture of seven spring-return mortar carriages for 12-inch B. L. mortars, under contract dated April 17, 1893.

Progress has been made in drawings and patterns, but the work of casting has not yet begun.

Very respectfully, your obedient servant,

W. B. GORDON,
Captain, Ordnance Department, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4051-'93.)

APPENDIX 35.

REPORT OF THE BOARD FOR TESTING RIFLED CANNON, ETC., APPOINTED UNDER THE ACT OF CONGRESS APPROVED JULY 1, 1884.

(1 plate.)

FINAL REPORT OF THE TEST OF THE 12-INCH B. L. RIFLE, CAST-IRON, STEEL, HALF TUBE, SOUTH BOSTON IRON WORKS; SUPPLEMENTAL TO PROGRESS REPORT MADE BY THE BOARD NOVEMBER 5, 1891.

Firing was resumed with this gun on October 25, 1892. Since the last firing the Powlett pneumatic carriage, upon which the gun is mounted, had been altered by making the recoil cylinders hydraulic instead of pneumatic.

Up to the date of resumption of firing the gun had been fired 238 rounds, of which 225 rounds gave the required pressure and velocity, leaving 25 rounds to be fired with full charges.

Of these, 19 rounds have now been fired for endurance and 6 for accuracy.

The maximum charge of powder was 275 pounds. Du Pont's N. V., lot 11, the same powder that had been used in previous firings of the test, and the pressure was about 31,000 pounds.

The projectiles used were cast-iron cored shot, proving-ground lot 198, weighing from 805 to 816 pounds natural weight.

The following table shows the results of the firings for accuracy:

Accuracy.

[Fired at 3,000-yards target; charge, 275 pounds Du Pont's brown prismatic powder N. V., lot 11.]

Weight of shot	pounds..	809
Deviation from center of impact:		
Vertical	feet..	2,500
Horizontal	do...	2,166
Mean	do...	3,446
Deviation center of impact from line of fire	do...	11.79
Wind:		
Direction	degrees..	Rear.
Force	miles..	26
Number of shots		6

The gun was star gauged before round 239 and after round 260.

The total number of rounds fired to complete the test of the gun was 263, as shown by the accompanying table. After the test the gun was thoroughly cleaned out and inspected by the board. The line of union

between the steel tube of bore and the cast iron was very marked and the powder chamber and bore pitted with small indentations of a slightly elongated shape to a peculiar and marked extent.

The star-gauge record, showing diameters before and after the test, is appended herewith.

The obturating pad of the breechblock was covered throughout these firings with thin sheet copper to protect it against the cutting edges of the cups. This arrangement worked very well, completely checking the gas and preventing cutting.

In round 252 the vent shield was broken and during the remaining rounds was removed entirely; and in round 255 the breechblock closed with some difficulty, probably due to slight sticking of gas-check cups. With these exceptions the gun was manipulated successfully.

CONCLUSION.

A contract for this gun was made under the provisions of an act of Congress approved March 3, 1883. The gun originally was to have been made with a steel lining tube as far as the trunnions, wrapped with steel wire, but on account of the difficulty in obtaining suitable wire, the tube was inserted in the gun under a slight shrinkage and the wire dispensed with.

The cast-iron body was made from the fourth casting, the three attempts previous to this having been unsuccessful.

Again there seems to have been difficulty in inserting the tube, three attempts being made to successfully accomplish the result.

The gun has withstood the number of rounds specified for its test and can not be said to be in an unserviceable condition, although it must be noticed that the pitting of the tube in the shot chamber is most marked and peculiar and the enlargement at the beginning of the rifling is .07 of an inch. The gun is essentially a low-power gun.

The muzzle energy is 16,000 foot-tons, about equal to that of the 10-inch B. L. rifle, steel (of about half the weight), the cast-iron gun, tubed, weighing 54 tons, and the 10-inch B. L. rifle, steel, 28 tons. The gun also weighs two tons more than the 12-inch B. L. rifle, steel, which develops a muzzle energy of 27,040 foot-tons.

The development of a gun metal with great tensile and elastic strength has necessarily been the result of the great strides made in science of gun-making in the last comparatively few years. Strength, elasticity, endurance, and safety are matters of importance which must be considered in the manufacture of the powerful engines of war of the present day, and these factors have been of great moment in selecting a material more suited for this purpose than cast iron.

Again, the difficulty of making sound and strong castings of the immense weight required by a gun of this size would seem to preclude its use when by building a gun from smaller pieces, well selected, a stronger, safer, and more powerful weapon is obtained.

The number of failures attending the manufacture of this gun may be no criterion as to what may result in future in castings of similar size, yet it is presumed that every care was exercised in the operations.

In view of the foregoing considerations the board does not recommend this gun as suitable to be put to use in the Government service.

Table of rounds.

Object of firing.	Rounds.	Charge.	Velocity.	Pressure.	Total.
Endurance; also to determine suitability of powder	1	200	.....	20,500	.....
	1	240	.....	24,300	.....
	1	260	.....	28,200	6
	1	270	1,705	28,400	.....
	2	275	1,749	30,600	.....
Endurance	2	275	.....	30,500	2
	1	200	.....	{Less than 28,000}	.....
	1	258	.....	28,500	.....
	1	262	.....	28,650	.....
	1	266	.....	29,000	.....
	1	272	.....	31,000	.....
	91	275	1,730	31,500	179
	2	265	.....	34,000	.....
	2	255	.....	33,000	.....
	26	245	1,734	31,000	.....
	41	250	.....	30,000	.....
	12	270	.....	31,000	.....
Endurance; also to test workings of Powlett pneumatic carriage	1	150	1,231	11,800	.....
	1	200	1,467	18,200	.....
	1	225	.....	21,150	6
	2	250	1,648	24,600	.....
	1	275	1,737	30,000	.....
To determine correctness of pressure	2	275	1,713	28,060	2
Endurance; also in proof of powder	1	260	1,723	30,800	.....
	1	265	1,731	31,600	.....
	1	260	1,794	35,500	.....
	2	254	1,735	36,800	.....
	1	200	1,533	21,500	.....
	1	250	1,730	31,000	.....
	1	255	1,759	31,500	.....
	3	265	1,794	33,000	.....
	1	200	1,559	23,700	.....
	1	255	1,778	34,500	24
	1	250	1,752	34,080	.....
	1	240	1,721	32,800	.....
	1	230	1,716	34,960	.....
	1	220	1,659	33,800	.....
	1	225	1,604	{Less than 28,000}	.....
	2	250	1,730	29,000	.....
	1	200	1,567	21,140	.....
	1	225	1,627	26,500	.....
	2	250	1,735	30,000	.....
To determine range	15	270	.....	31,000	15
For accuracy	15	250	.....	29,000	21
For rapidity	6	275	.....	31,000	.....
	8	250	.....	29,000	8
Total	263	.....	.....	.....	263

CLIFTON COMLY,
Major, Ord. Dept., U. S. Army, Senior Member Present.
J. W. REILLY,
Major, Ordnance Department, U. S. Army.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
CHARLES B. WHEELER,
Lieutenant, Ord. Dept., U. S. Army, Recorder.

Record of firing with 12-inch B. L. rifle (cast iron), steel tube (54 tons),

[Object of firing to

	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.
		Kind.	Number of prisms.	Weight.	Kind.	Weight.		
				Lbs.		*Lbs.*	*Inches.*	° ′
A. M.	239	Du Pont's brown prismatic N. V., lot 11; density, 1.825.	Brown. 812 Brown. 1,343 Black.. 7	Front cartridge. 75 Rear cartridge.. 125 200	Cored shot, single band, lot 198.	809 natural weight.	272.05	1 00
	240		Brown. 1,350 Brown. 1,343 Black.. 7	Front cartridge. 125 Rear cartridge.. 125 250		807 natural weight.	273.0	1 00
	241		Brown. 1,350 Brown. 1,430 Black.. 7	Front cartridge. 125 Rear cartridge.. 133 258		810 natural weight.	272.05	1 00
	242		Brown. 1,350 Brown. 1,473 Black.. 7	Front cartridge. 125 Rear cartridge.. 137 262		812 natural weight.	272.05	1 00
	243		Brown. 1,350 Brown. 1,516 Black.. 7	Front cartridge. 125 Rear cartridge.. 141 266		812 natural weight.	272.5	1 00
P. M.	244		Brown. 1,350 Brown. 1,581 Black.. 7	Front cartridge. 125 Rear cartridge.. 147 272		805 natural weight.	273.5	1 00
	245		Brown. 1,350 Brown. 1,614 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		808 natural weight.	273.0	1 00
	246		Brown. 1,349 Brown. 1,614 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		811 natural weight.	273.0	1 00
	247		Brown. 1,350 Brown. 1,614 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		808 natural weight.	273.1	1 00

South Boston Iron Works, at Sandy Hook, N. J., October 25, 1892.

test gun for endurance.]

Pressure per square inch of bore.	Recoil.	Wind, strength and direction.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Pounds.	*Ft. In.*		*Ft. In.*		
B, less than 28,000. M, less than 28,000.	5 8	From rear 18°, 6 miles an hour.	.....	Carriage came in battery and struck buffers and rebounded; buffers compressed 3 inches; stuffing boxes of cylinders tightened.	
B, less than 28,000. M, less than 28,000.	6 8		6 9	Nut on spindle of mushroom-head tightened; buffers compressed 1 inch.	Gun mounted on Powlett carriage, with hydraulic cylinders. Forty-five gallons of oil in each cylinder; depth, 8⅛ inches. Pad covered with thin sheet copper. Copper cylinders of 28,000 pounds initial compression and tables of 1890. Chamber sponged out after each round. Fired to sea. Obturating friction primers. Barometer, 30.07; thermometer, 43°; humidity, 38.
B, 28,746 M, 28,600	.....		.....	Top carriage moved slightly to the left and recoil marker did not register recoil.	
B, 29,800 M, 29,150	6 6		1 0	End of primer burnt slightly.	
B, 28,920 M, 29,720	6 10		6 10	.....	
B, 31,340 M, 31,500	6 11½	From rear 18°, 8 miles an hour.	6 11½	Carriage in recoiling struck rear buffers.	
B, 31,320 M, 31,380	7 0		7 0	Carriage in recoiling struck rear buffers.	Gun mounted on Powlett carriage, with hydraulic cylinders. Copper cylinders of 28,000 pounds initial compression and tables of 1890. Obturating friction primers. Fired to sea.
B, 28,640 M, 29,750	7 0		7 0	Carriage in recoiling struck rear buffers.	
.....	7 0		7 0	Carriage in recoiling struck rear buffers.	

Record of firing with 12-inch B. L. rifle (cast iron, steel tube), South Boston

[Object of firing, to

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Sighting.
		Kind.	Number of prisms.	Weight.	Kind.	Weight.		Elevation.
P. M.				*Lbs.*		*Lbs.*	*Inches.*	
Oct. 27	248	Du Pont's brown prismatic N. V., lot 11; density, 1.825.	Brown. 1,353 Brown. 1,617 Black.. 7	Front cartridge.. 150 Rear cartridge... 125 275	Cored shot, lot 198.	814 natural weight.	.....	Quadrant, 3° 20′. Sight, 3° 10′.
Oct. 27	249		Brown. 1,353 Brown. 1,614 Black.. 7	Front cartridge.. 150 Rear cartridge... 125 275		810 natural weight.	.....	Quadrant, 2° 40′. Sight, 2° 30′.
Oct. 27	250		Brown. 1,353 Brown. 1,614 Black.. 7	Front cartridge.. 150 Rear cartridge... 125 275		810 natural weight.	.....	Quadrant, 2° 58′. Sight, 2° 48′.
Oct. 27	251		Brown. 1,353 Brown. 1,614 Black.. 7	Front cartridge.. 150 Rear cartridge... 125 275		810 natural weight.	.....	Quadrant, bubble horizontal. Sight, 2° 47′.
Oct. 27	252		Brown. 1,353 Brown. 1,614 Black.. 7	Front cartridge.. 150 Rear cartridge... 125 275		810 natural weight.	.....	.....
Nov. 9	253		Brown. 1,352 Brown. 1,614 Black.. 7	Front cartridge.. 125 Rear cartridge... 150 275		816 natural weight.	272⅞	2° 48′
Nov. 9	254		Brown. 1,352 Brown. 1,613 Black.. 7	Front cartridge.. 125 Rear cartridge... 150 275		810 natural weight	272⅞	2° 48′

Iron Works, at Sandy Hook, N. J., October 27 and November 9, 1892.

test gun for accuracy.]

Sighting. Deflection points, left.	Pressure, per square inch of bore.	Recoil.	Wind, strength and direction.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
	Pounds.	*Ft. In.*	*Ft. In.*	*Ft. In.*		
$3\frac{7}{16}$	B, 30,800 M, 31,100	7 0	.....	7 0	Wind right and rear 5°; fired at 2′ 17″; struck about 200 yards beyond and on line.	Gun mounted on Powlett carriage, fitted with hydraulic cylinders. Obturating friction primers. Fired at 3,000-yards target. Aimed at center. A recoil of 7 feet; struck buffers. Zalinski fortification artillery sight used. The elevation of Zalinski sight was 0 when quadrant read 10 minutes. Upper part of vent shield bent, causing some difficulty in opening breechblock. Barometer, 29.97; thermometer, 59°; humidity, 43. Sights: *Inches.* Face of trunnion to axis ..... 34.5 Center of sight to face of trunnion ..... 8.35 42.85 3.58 feet from axis of gun to axis of sight. 1 point = 5.28 ft. at a mile. $2\frac{1}{4}$ 11.88 3.58 5.28) 8.30 1.57 It took $2\frac{1}{4}$ points to bring sight from its 0 to same point gun was aimed at. Pressures taken by First Lieut. E. St. J. Greble, Second U. S. Artillery. Target observed by Lieut. F. P. Peck, Ordnance Department, U. S. Army.
$3\frac{7}{16}$	B, 31,320 M, 31,600	7 0	.....	7 0	Fired at 2′ 40″; wind same direction; struck 150 yards in front, 4 feet to the right of center.	
$3\frac{7}{16}$	B, 31,600 M, 32,500	7 0	.....	7 0	Wind right and rear 5°, $13\frac{1}{3}$ miles an hour; struck target $3\frac{1}{2}$ feet above, $5\frac{1}{2}$ feet left; wind increasing in velocity.	
$3\frac{7}{16}$	B, 30,200 M, 33,160	7 0	.....	7 0	Wind right and rear 5°, 17.1 miles an hour; horizontal wire in sight is tangent to top of bull's-eye; fired at 3′ 42″; struck 8 feet above, $5\frac{1}{2}$ feet left.	
$3\frac{7}{16}$	B, 29,363 M, 31,680	7 0	.....	7 0	Wind right and rear 5°, 10 miles an hour; cross hair nearly splitting bull's-eye; fired at 4′ 17″, $6\frac{1}{2}$ feet below, $7\frac{3}{4}$ feet left.	
.....	P, 31,700 X, 31,400	6 11	From rear, 11 miles an hour.	6 11	Deflection of sight set at 0; the vertical hair sighted on left-hand edge of target; struck 30 yards in front, 22 feet from right edge.	Gun mounted on Powlett carriage, fitted up with hydraulic cylinders. Fired at 3,000-yards target. Obturating friction primers. Copper cylinders of 28,000 pounds initial compression and tables of 1890. Vent shield repaired before this firing. Barometer, 30.51; thermometer, 46°; humidity, 66. Firing conducted by First Lieut. E. St. J. Greble, Second Artillery.
.....	.....	6 11		6 11	Deflection of sight set at 2 points left; the vertical hair sighted on left-hand edge of target; struck 12 feet below and near the right-hand corner.	

Record of firing with 12-inch B. L. rifle (cast iron), steel tube (54 tons),

[Object of firing, to

	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Deflection points, left.
		Kind.	Number of prisms.	Weight.	Kind.	Weight.			
				Lbs.		*Lbs.*	*Inches.*	° ′	
	255	Du Pont's brown prismatic N. V., lot 11; density, 1.825.	Brown. 1,353 Brown. 1,616 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275	Shell, lot 198.	809 natural weight.	273	2 50	2
	256		Brown. 1,353 Brown. 1,616 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		809 natural weight.	272⅞	2 50	2
	257		Brown. 1,353 Brown. 1,617 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		809 natural weight.	272⅞	2 50	2
P. M.	258		Brown. 1,350 Brown. 1,613 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		809 natural weight.	272⅞	2 50	2
	259		Brown. 1,350 Brown. 1,616 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		810 natural weight.	272⅞	2 50	2
	260		Brown. 1,352 Brown. 1,617 Black.. 7	Front cartridge. 125 Rear cartridge.. 150 275		812 natural weight.	272⅞	2 50	2

South Boston Iron Works, at Sandy Hook, N. J., December 2, 1892.

test gun for accuracy.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Wind, strength and direction.	From center of target.				From center of impact.				General remarks.
				Vertical.		Horizontal.		Vertical.		Horizontal.		
				Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
Pounds.	*Feet.*	*Feet.*										
P 31,490 X 31,360	7	7		....	7.25	...	5.5	.....	2.625	3.0	...	Gun mounted on Powlett carriage, fitted up with hydraulic cylinders. 1½ gallons of oil added to cylinders. Fired at 3,000-yards target. Vertical hair placed on left edge of target; horizontal hair tangent with top of bull's-eye.
P 32,200 X 32,270	7½	7½		2.25	....	...	5.0	6.875	.....	3.5	...	Copper cylinders of 28,000 pounds initial compression and tables of 1890. In closing, the rotation of breechblock in last two turns made with some difficulty. Fired at 1:05 p. m. Center of impact: *Feet.* Below ..... 4.625 Left ..... 8.5 Mean vertical deviation from center of impact ..... 2.500 Mean horizontal deviation from center of impact ..... 2.166 Mean deviation from center of impact 3.446
P 31,870 X 31,950	7	7	From rear, 26 miles an hour.	....	5.25	...	11.5	.....	.625	...	3.0	
P 32,000 X 32,000	7	7		....	7.25	...	10.0	.....	2.625	...	1.5	The change of 1 point left in round 256 was thought necessary. In computing the center of impact this change has been taken into account. One point of this sight at 3,000 yards equals 9 feet. Zalinski fortification artillery sight used.
P 30,545 X 30,545	7	7		....	6.25	...	10.0	.....	1.625	...	1.5	The gun for first shot (round 255) was laid 3 points left, and the shot struck 7.25 feet low and 14.5 feet left. Barometer, 30.01; thermometer, 41°; humidity, 53. Gun sighted by First Lieut. E. St. J. Greble, Second Artillery. Target observed by Lieut. F. P. Peck, Ordnance Department
P 30,760 X 30,760	7	7		....	4.0	...	9.0	.625	.....	- -	.5	Firing conducted by First Lieut. E. St. J. Greble, Second Artillery, in the presence of the testing board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.

Record of firing with 12-inch B. L. cast-iron rifle (steel tube), South

{Object of firing, to test

	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.
		Kind.	Number of prisms.	Weight.	Kind.	Weight.		
				Lbs.		*Lbs.*	*Inches.*	° ′
A. M ...	261	Du Pont's brown prismatic N.V., lot 11; density, 1.825.	Brown. 1,350	Front cartridge.. 125	Shell, lot 198.	804 natural weight.	273.00	1 00
			Brown. 1,613	Rear cartridge... 150				
			Black.. 7					
				275				
	262		Brown. 1,350	Front cartridge.. 125		805 natural weight.	272.90	1 00
			Brown. 1,613	Rear cartridge... 150				
			Black.. 7					
				275				
	263		Brown. 1,350	Front cartridge.. 125		814 natural weight.	272.90	1 00
			Brown. 1,613	Rear cartridge... 150				
			Black.. 7					
				275				

Boston Iron Works, at Sandy Hook, N. J., December 6, 1892.

gun for endurance.]

Recoil.	Wind, strength and direction.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Ft. In.		*Ft. In.*		
6 11½	From right and rear, 12 miles an hour.	6 11½	First primer failed; wires pulled out.	Gun mounted on Powlett carriage, fitted with hydraulic cylinders. Obturating friction primers. Shot gauged before firing. Fired to sea. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, assistant proof officer, in the presence of the testing board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department.
7 0		7 0	.....	
7 0		7 0	Pad cutting slightly	

Star gauging of 12-inch B. L. rifle (cast iron), steel tube (54 tons), South Boston Iron Works.

[12-inch ring.]

From muzzle.	Before firing, Dec. 28, 1889 (lands).	After firing, Dec. 3, 1892.	Increase.	From muzzle.	Before firing, Dec. 28, 1889 (lands).	After firing, Dec. 3, 1892.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
1½	12.000			146	12.002		
3½	12.00			148	12.0025		
5½	12.00			150	12.003		
7½	12.001			152	12.0025		
9½	12.001			154	12.002	12.012	.010
11½	12.0015			156	12.002		
13½	12.002			158	12.002		
15½	12.0025			160	12.002		
16	12.003			162	12.002		
18	12.002			164	12.0015		
20	12.002			166	12.002	12.017	.015
22	12.0025			168	12.002		
24	12.002	12.0105	.0085	170	12.002		
26	12.002			172	12.003		
28	12.002			174	12.003		
30	12.002			176	12.002		
32	12.0015			178	12.002	12.025	.023
34	12.002			180	12.001		
36	12.002	12.0115	.0095	182	12.003		
38	12.002			184	12.002		
40	12.002			186	12.002		
42	12.0015			188	12.002		
44	12.002			190	12.001	12.011	.010
46	12.002			192	12.001		
48	12.002	12.01	.008	194	12.0015		
50	12.002			196	12.001		
52	12.0025	12.01	.0075	198	12.002		
54	12.002			200	12.002		
56	12.002			202	12.0025	12.009	.0065
58	12.002			204	12.0025		
60	12.0015			206	12.003		
62	12.002			208	12.002		
64	12.001	12.01	.009	210	12.002		
68	12.002			212	12.002		
70	12.002			214	12.002	12.0105	.0085
72	12.002			216	12.002		
74	12.002			218	12.002		
76	12.002	12.009	.007	220	12.002		
78	12.002			222	12.002		
80	12.002			224	12.001		
82	12.002			226	12.0015	12.014	.0125
84	12.002			228	12.002		
86	12.002			230	12.002		
88	12.002	12.009	.007	232	12.002	12.02	.018
90	12.002			234	12.002		
92	12.003			236	12.002	12.0225	.0205
94	12.002			238	12.002		
96	12.0025			240	12.003	12.026	.023
98	12.003			242	12.0025		
100	12.002	12.01	.008	244	12.002	12.032	.030
102	12.002			246	12.003		
104	12.003			248	12.002	12.04	.038
106	12.003			250	12.002		
108	12.003			252	12.002	12.044	.042
110	12.003			254	12.003		
112	12.002	12.011	.009	256	12.002	12.0485	.0465
114	12.002			258	12.002	12.0515	.0495
116	12.003			260	12.002	12.0545	.0525
118	12.003	12.01	.007	261	12.002		
120	12.0025			262	12.002	12.059	.057
122	12.0025			263	12.002		
124	12.0025			264	12.002	12.065	.063
126	12.003			265	12.002		
128	12.003			266	12.002	12.073	.071
130	12.002	12.0105	.0085	267	12.002		
132	12.0025			268	12.002		
134	12.002			269	12.002		
136	12.0025			269½	12.002		
138	12.0025			270	12.004		
140	12.002			270⅓	12.065		
142	12.002	12.011	.009	271	12.126		
144	12.003						

Fixed point on land, over S. of tons; one point on lands between 1 and 2 of 12; one point on third land to right of W. of S. B. I. W.

Temperature outside bore, 38½°; temperature inside bore, 37½°; time, 11:10 to 11:30 a. m.

Star gauging of 12-inch B. L. rifle (cast-iron), steel tube (54 tons), South Boston Iron Works—Continued.

[13.5-inch ring.]

From breech.	Before firing, Dec. 30, 1889.	After firing, Dec. 3, 1892.	Increase.	From breech.	Before firing, Dec. 30, 1889.	After firing, Dec. 3, 1892.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
21	13.507	13.512	.005	44	13.502	13.512	.010
21½	13.507			45	13.502		
22	13.507			46	13.502		
22½	13.507			47	13.503		
23	13.507			48	13.503	13.5135	.0105
24	13.507	13.514	.007	49	13.502		
24½	13.507			50	13.503		
25	13.507			51	13.5025		
25½	13.507			52	13.503	13.515	.012
26	13.507			53	13.502		
26½	13.507			54	13.503		
27	13.506			55	13.503		
27½	13.507			56	13.503	13.518	.015
28	.....	13.516		57	13.503		
28½	13.507			58	13.503		
29½	13.507			59	13.503		
30	13.506			60	13.503	13.5215	.0185
30½	13.506			61	13.503		
31	13.506			62	13.5025		
31½	13.506	13.517		63	13.503		
31¾	.....	13.517		64	13.503	13.527	.024
32	13.506	13.516	.010	65	13.503		
32¼	.....	13.512		66	13.503		
33	13.501			67	13.5035		
34	13.501			68	13.5035	13.5325	.0290
35	13.5015			69	13.503		
36	13.501	13.5105	.0095	70	13.504		
37	13.501			71	13.504		
38	13.5015			72	13.504	13.539	.035
39	13.5015			73	13.506		
40	13.5015	13.5105	.0090	74	13.506		
41	13.502			75	13.507		
42	13.502			76	13.503	13.5385	.0355
43	13.502			77	13.516		

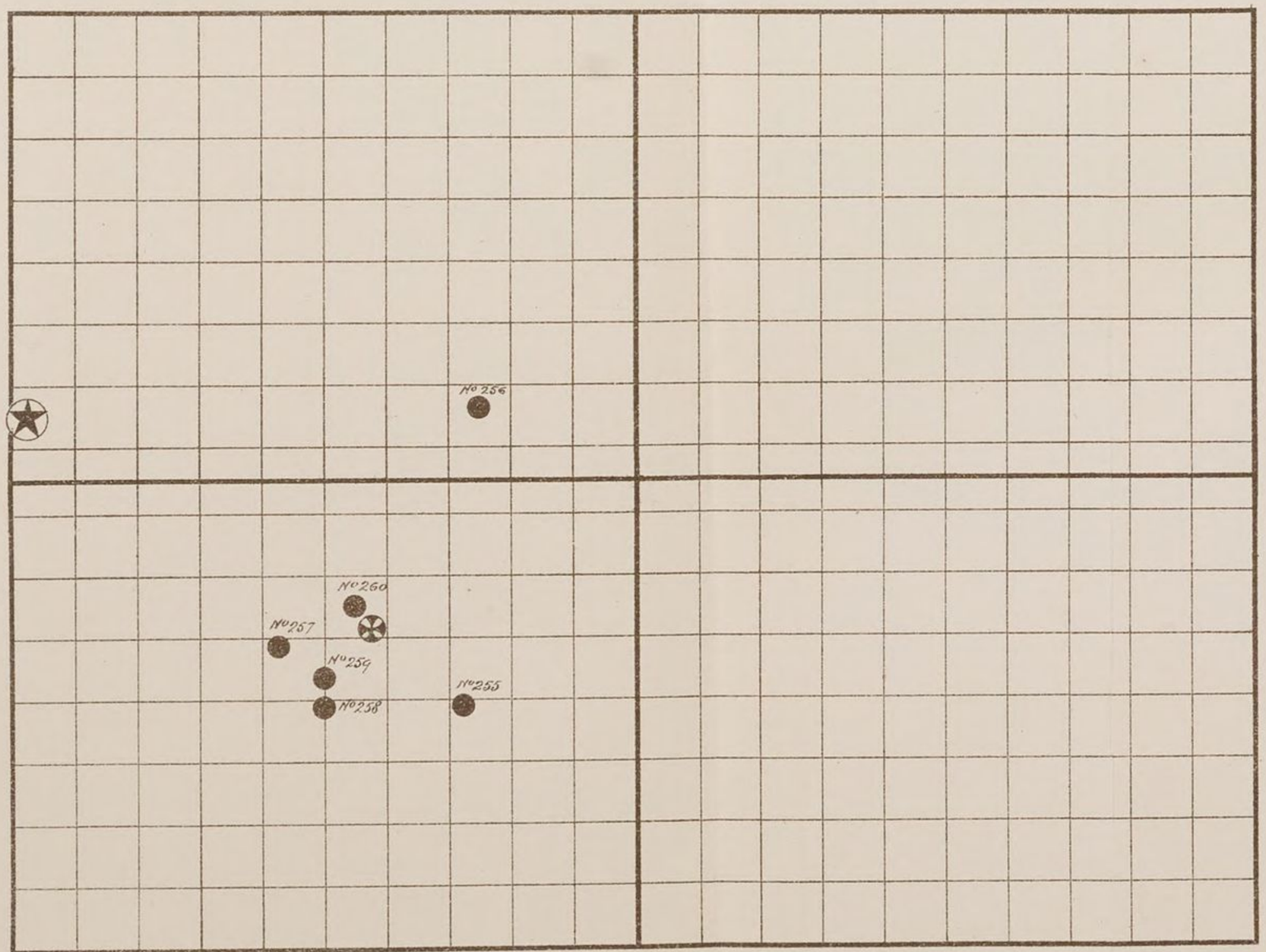
Temperature outside breech, 37½°; temperature inside breech, 36½°; time, 11:40 a. m. to 12 m.

TARGET RECORD of *12inch B.L.Rifle, Cast-iron, Steel tube.*

AT SANDY HOOK, N. J. *Dec. 2nd 1892.*

Target 3000 yards *from Gun.*

Number of shots fired, 6 . *Direct hits,* 6 . *Ricochet hits,* 0 . *Misses,* 0 .



Center of impact.

Point aimed at.

Target 30' × 40'.

v = *Mean vertical deviation from center of impact,* 2.500 feet .

h = *Mean horizontal deviation from center of impact,* 2.166 feet .

Mean deviation from center of impact, 3.301 feet } *as obtained by method used in computing this value for previous targets and which* $= \sqrt{v^2+h^2}$

Mean deviation from center of impact $= \frac{2\sqrt{a^2+b^2}}{6} = 3.446$ ft.

Gun sighted by Lieut. E. St. J. Greble 2nd Arty. U.S.A.

Target observed by Lieut. F. P. Peck Ord. Dept. U.S.A.

Wind 26 *miles per hour. from rear.*

APPENDIX 36.

FINAL REPORT ON THE TEST OF THE HOTCHKISS 3-INCH B. L. MOUNTAIN RIFLE, BY THE BOARD FOR TESTING RIFLED CANNON, ETC., APPOINTED UNDER THE ACT OF CONGRESS APPROVED JULY 5, 1884.

SANDY HOOK, N. J., *September 22, 1893.*

The Hotchkiss 3-inch B. L. mountain rifle was turned over to the board at the Sandy Hook Proving Ground, Sandy Hook, N. J., for test, in compliance with instructions of the Chief of Ordnance, U. S. Army, dated December 26, 1891.

On June 13, 1892, a progress report was submitted to the Chief of Ordnance, U. S. Army, giving a description of the piece and carriage and the results of firing to that date after 552 rounds. Since that date the uncompleted portion of the programme, referring to accuracy, range, and efficiency of the shrapnel, has been carried out, and the firing has been continued to 1,000 rounds, thus completing the programme prescribed by the board.

Following is a summary of the results of firing for accuracy, range, and test of shrapnel:

Direct fire with common shell.

Distance of target.	Number of rounds fired.	Hits.	Misses.	Mean vertical deviation from center of impact.	Mean horizontal deviation from center of impact.	Mean deviation from center of impact.
				Feet.	*Feet.*	*Feet.*
1,000 yards	10	7	3	4.94	1.08	5.06
1 mile	10	3	7	5.56	4.00	6.85

Vertical fire with half charges (shell).

Number of rounds fired.	Elevation.	Greatest range.	Least range.	Maximum dispersion in range.	Mean range.	Mean lateral deviation from center of impact.
	Degrees.	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*
5	5	587	477	110	519.2	0.48
5	10	969	726	243	875.8	10.48
5	15	1,446	1,257	189	1,343.4	1.04

Vertical fire with full charges (shrapnel).

5	11	2,281	2,129	152	2,217.8	2.96
5	14	2,667	2,583	84	2,635.4	9.12
5	17	3,100	3,020	80	3,054.8	8.88
5	20	3,519	3,307	212	3,410.4	16.32

Efficiency of shrapnel at 1,000 yards.

[Fired to burst on striking a 1-inch board screen 90 feet in front of target; target, 18 feet high by 52 feet wide.]

Number of shots fired	7	Fragments through, mean	14
Hits on screen	2	Fragments embedded, mean	4
		Fragments made mark, mean	1
Balls through, mean	96		
Balls embedded, mean	11	Total hits on target, mean	141
Balls made mark, mean	15		

Efficiency of shrapnel at 1 mile.

[Fired to burst on passing through target, scattering fragments on four screens 75 feet apart in rear of target; each screen 6 feet high by 52 feet wide.]

Number of shots fired.	Hits on target.	Mean number of hits on—				Total number of hits (mean).
		First screen.	Second screen.	Third screen.	Fourth screen.	
4	2	26	39	12	6	83

On August 29, 1892, three shrapnel were fired to burst on striking a screen 60 feet in front of the 3,000-yards target, but no hits being obtained the test for efficiency at this range was discontinued.

Direct fire with shrapnel.

Distance of target.	Number of rounds fired.	Hits.	Misses.	Mean vertical deviation from center of impact.	Mean horizontal deviation from center of impact.	Mean deviation from center of impact.
				Feet.	*Feet.*	*Feet.*
1,000 yards	8	6	2	2.33	4.41	4.99
1 mile	8	3	5	5.89	4.44	7.38

ENDURANCE.

The piece has been fired 1,000 rounds, nearly all of which have been with full charges, without material injury to the bore.

BREECH MECHANISM.

The breech mechanism has worked well, except when using a cartridge case repeatedly without resizing. After firing four or five rounds consecutively with one case it has generally been necessary to ram the block home and use a tool to extract the case; in this way the inner thread of the locking screw has been broken by ramming after the block had advanced far enough for the thread to have a bearing. This has occurred twice during the test; first at the sixty-sixth round, a new one being fitted to the block at Sandy Hook before the seventieth round, and second at the one hundred and ninety-seventh round, but this time it was only cracked and was not repaired till after the eight hundred and eightieth round; again before the completion of the test it was bent, causing the block to lock and unlock with difficulty. This fault is entirely due, however, to the fact of ramming the block, and it is believed would not exist in service conditions.

AMMUNITION.

The use of cut-off cartridge cases and independent loading of case and projectile have been continued because of the limited quantity of ammunition on hand, and the cylindrical shot with which the test for endurance was begun have served to complete the test by being repeatedly rebanded. By this independent loading it has been possible to use the cases in several rounds consecutively, and some particular cases have been used for a large number of rounds. Without cleaning either the case or the chamber they may generally be fired four or five rounds before giving trouble in closing the block or in extracting, but if the chamber is sponged out and the case cleaned and oiled after each round they will generally last for ten or fifteen rounds without sticking, and again after they begin to stick it is still possible to use them, by ramming the block, often for fifteen or twenty rounds more, though this is not advisable, as being liable to break the locking screw, as mentioned above.

The vent in the case for the gases of the primer is often nearly closed by the obturator inside the case and becomes easily fouled, thus causing many failures of the primers to ignite the charge, but not so many as appears from the firing record, for a large number of these were due to defective primers, which burned out at the top only.

Both shell and shrapnel weigh 12 pounds when loaded and fused, the bursting charges being 6.3 ounces and $1\frac{3}{4}$ ounces, respectively.

ACCURACY AND RANGE.

The accuracy of fire, both direct and vertical, though much inferior to that of high-power field guns, is creditable for a gun of this type. The greatest range obtained with a full charge at 20 degrees elevation was 3,519 yards. A higher elevation and greater range may be obtained by sinking the trail in the ground, but practically the above is the maximum limit with the carriage as furnished.

On December 18, 1891, three rounds were fired with $13\frac{1}{2}$-ounce charges at 20 degrees elevation, giving a mean range of 3,887 yards; this was an excessive charge, however, and gave over the limit of permitted pressure.

The efficiency of the shrapnel at 1,000 yards and 1 mile compare favorably with that of the 3.2-inch shrapnel, but their maximum range of effectiveness must be somewhat less than the maximum range, or about 3,000 yards.

POWDER.

The powder used in the test was Du Pont's I. K. H., lot 27, density 1.725, and granulation 2,605. The full charge was 11 ounces, giving the maximum pressure of 14,225 pounds, for which the piece was constructed, and a mean velocity of about 870 feet.

CARRIAGE.

Four times during the test the nuts on bolts through the hubs of the wheels became loose enough to require tightening. At round 548 the axle plates were noticed to show signs of loosening, but this did not increase in after firing. At round 535 it was noted that the wheels were bending slightly forward, due to recoil; and at round 880 the axle broke off squarely with a clean fracture at the fillet just inside the hubs of both wheels.

A new axle was fitted to the carriage at Sandy Hook and the test was completed with it.

It has been impracticable to test the ability of the carriage and limber to stand transportation over rough roads, as would be required of them in service, but their substantial construction, coupled with lightness, seem to warrant the opinion that they would be found satisfactory in this respect.

CONCLUSION.

In conclusion the board finds that, with the exception noted below, the performance of the piece has been satisfactory throughout the test, and confirms the opinion expressed in its progress report, that pieces of this type may safely be put to use in the Government service.

OPINIONS.

Still the board is of the opinion that some one of the breech mechanisms known for fixed ammunition would be an improvement on the Hotchkiss sliding block for guns of this kind, and that a more satisfactory system of piece and carriage for mountain service can be procured by the Ordnance Department.

The accident that happened to the axle at the eight hundred and eightieth round being a serious one, and one for which there would be no remedy in the field, stronger metal should be used in its construction if any are put in service.

The service of the piece requiring the use of half and full charges in proportions which it would be impossible to anticipate, the board is of the opinion that it would be advantageous to employ the system of ammunition used in the test, viz, short cartridge cases, permitting independent loading of the projectile and case.

ISAAC ARNOLD, Jr.,
Major, Ord. Dept., U. S. Army, President.
CLIFTON COMLY,
Major, Ordnance Dept., U. S. Army.
J. W. REILLY.
Major, Ordnance Dept., U. S. Army.
FRANK HEATH,
Captain, Ordnance Dept., U. S. Army.
FREMONT P. PECK,
Lieutenant, Ord. Dept., U. S. Army, Recorder.

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points, left.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
			Ounces.		*Lbs. Oz.*	° ′		*Feet.*
P. M	506	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Shrapnel, lot 294; shell rebanded with Frankford Arsenal point percussion fuse.	11 6 3 sand. 11 9	4 35	.....	16
	507		11		11 6 3 sand. 11 9	4 30	.....	17
	508		11		11 7 3 sand. 11 10	4 30	.....	17
	509		11		11 11 2 powder, bursting charge. 11 13	4 28	1	17
	510		11		11 11 2 powder, bursting charge. 11 13	4 25	½	16
	511		11		11 11 2 powder, bursting charge. 11 13	4 25	¾	16
	512		11	Shrapnel, lot 294; shell rebanded with Frankford Arsenal point percussion fuse.	11 11 2 powder, bursting charge. 11 13	4 25	1½	16
	513		11		11 12 2 powder, bursting charge. 11 14	4 25	1½	17
	514		11		11 12½ 2 powder, bursting charge. 11 14½	4 23	1½	16
	515		11		11 13½ 2 powder, bursting charge. 11 15½	4 21	1½	16½
	516		11	Shrapnel, lot 294, with Frankford Arsenal point percussion fuse.	11 13½ 2 powder, bursting charge. 11 15½	4 21	1½	17

(*weight 219 pounds*), *at Sandy Hook, N. J., August 8, 1892.*

the efficiency of shrapnel.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From front.	Sighting shot; new case used. Shot struck 100 yards in rear of target.	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887. The same cartridge case used in rounds 506 to 510, inclusive. Axle and box of right wheel scored. Fired to burst on passing through screen placed 90 feet in front of 1,000-yards target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. The same cartridge case used in rounds 511 to 516, inclusive. Before this firing upper end of sight bent forward, caused probably by the recoil. Horizontal slide has considerable play. Barometer, 30.20; thermometer, 81°; humidity, 73. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Sighting shot. Missed screen; struck target 14 feet right and 5½ feet above center.	
	Sighting shot. First primer failed to ignite charge. Shot missed screen and struck about 75 yards in rear of target.	
	Shrapnel missed screen; struck about 125 yards in rear of target. Did not burst.	
	Shrapnel missed screen; struck target 13 feet right and 2 feet below center, passed through, and burst.	
	Shrapnel missed screen; struck target 9 feet right and 2 feet below center, passed through, and burst. New case used in this round.	
	Shrapnel struck 100 yards in rear of target and burst.	
.....	Shrapnel struck about 125 yards in rear of target and ricocheted into the water.	
.....	Shrapnel missed screen; struck target 8½ feet above and 2 feet left of center, passed through, and burst.	
.....	First primer failed to ignite charge. Shrapnel struck the screen 1½ feet right of center, passed through, and burst. Number of hits on target as follows: Balls through ..... 110 Balls embedded ..... 13 Balls made mark ..... 14 Fragments through ..... 13 Fragments embedded ..... 2 Fragments made mark ..... 1 Total 153	
.....	Shrapnel struck the screen 1 foot below and 1½ feet left of center, passed through, and burst. Number of hits on target as follows: Balls through ..... 82 Balls embedded ..... 8 Balls make mark ..... 16 Fragments through ..... 16 Fragments embedded ..... 5 Fragments made mark ..... 1 Total 128	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
A. M.			*Ounces.*		*Lbs. Oz.*	° ′		*Feet.*
Aug. 9	517	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	17
Aug. 9	518		11		12 0	.....	.....	17
Aug. 9	519		11		12 0	.....	.....	17
Aug. 9	520		11		12 0	.....	.....	18
Aug. 9	521		11		12 0	.....	.....	18
Aug. 9	522		11		12 0	.....	.....	17
Aug. 9	523		11		12 0	.....	.....	17
Aug. 9	524		11		12 0	.....	.....	17
Aug. 9	525		11		12 0	.....	.....	18
Aug. 9	526		11		12 0	.....	.....	19
Aug. 9	527		11		12 0	.....	.....	19
Aug. 9	528		11		12 0	.....	.....	18
Aug. 9	529		11		12 0	.....	.....	19
Aug. 9	530		11		12 0	.....	.....	19
Aug. 9	531		11		12 0	.....	.....	18
Aug. 9	532		11		12 0	.....	.....	17
Aug. 9	533		11		12 0	.....	.....	18
Aug. 9	534		11		12 0	.....	.....	18
Aug. 9	535		11		12 0	.....	.....	19
Aug. 9	536		11		12 0	.....	.....	17
Aug. 9	537		11		12 0	.....	.....	19
Aug. 9	538		11		12 0	.....	.....	18
Aug. 9	539		11		12 0	.....	.....	19
Aug. 9	540		11		12 0	.....	.....	19
Aug. 9	541		11		12 0	.....	.....	18
Aug. 9	542		11		12 0	.....	.....	17
Aug. 9	543		11		12 0	.....	.....	19
Aug. 9	544		11		12 0	.....	.....	18
Aug. 9	545		11		12 0	.....	.....	17
Aug. 9	546		11		12 0	.....	.....	18
Aug. 9	547		11		12 0	.....	.....	19
Aug. 9	548		11		12 0	.....	.....	19
Aug. 9	549		11		12 0	.....	.....	19
Aug. 9	550		11		12 0	.....	.....	19
Aug. 9	551		11		12 0	.....	.....	19
Aug. 9	552		11		12 0	.....	.....	18
Aug. 9	553		11		12 0	.....	.....	19
Aug. 9	554		11		12 0	.....	.....	19
Aug. 9	555		11		12 0	.....	.....	20
Aug. 9	556		11		12 0	.....	.....	20
Aug. 9	557		11		12 0	.....	.....	20
Aug. 9	558		11		12 0	.....	.....	25
Aug. 9	559		11		12 0	.....	.....	20
Aug. 9	560		11		12 0	.....	.....	20
Aug. 9	561		11		12 0	.....	.....	19
Aug. 9	562		11		12 0	.....	.....	19
Aug. 9	563		11		12 0	.....	.....	25
P. M.								
Aug. 9	564		11		12 0	.....	.....	20
Aug. 9	565		11		12 0	.....	.....	20
Aug. 9	566		11		12 0	.....	.....	20
Aug. 9	567		11		12 0	.....	.....	19
Aug. 9	568		11		12 0	.....	.....	19
Aug. 9	569		11		12 0	.....	.....	19
Aug. 9	570		11		12 0	.....	.....	19
Aug. 9	571		11		12 0	.....	.....	19
Aug. 9	572		11		12 0	.....	.....	19
Aug. 9	573		11		12 0	.....	.....	18
Aug. 9	574		11		12 0	.....	.....	17
Aug. 9	575		11		12 0	.....	.....	18
Aug. 9	576		11		12 0	.....	.....	20
Aug. 9	577		11		12 0	.....	.....	18
Aug. 9	578		11		12 0	.....	.....	17
Aug. 9	579		11		12 0	.....	.....	16
Aug. 9	580		11		12 0	.....	.....	20
Aug. 9	581		11		12 0	.....	.....	19
Aug. 9	582		11		12 0	.....	.....	19

(*weight 219 pounds*), *at Sandy Hook, N. J., August 9, 1892.*

gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From right and front.	New cartridge case used	
	Case entered with slight difficulty	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Rammer used to force block home. Chisel used to extract case.	
	New case used	
	Outside of case wiped off with moist waste. Shot could not be seated at proper position in bore, removed, and another inserted.	
	Case bent accidentally by dropping	
	Chisel used to extract case	
	Chamber and bore cleaned out. Case oiled; entered with difficulty; extracted with difficulty.	
	Chisel used to extract case	
	Primer hung fire. Chisel used to extract case	
	Rammer used to force block home. Chisel used to extract case.	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Gun cleaned and oiled thoroughly. Chisel used to extract case.	
		Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used.
	Chisel used to extract case	Rear sight straightened before this firing.
	Chisel used to extract case	Fired into field butt No. 2.
	Chisel used to extract case	Chamber sponged out after each round.
	Rammer used to force shot home. Chisel used to extract case.	Cannon friction primers, model 1887.
	New case used	Wheels of carriage evidently spreading outward, the bend being near shoulder of axle.
	Primer exploded, but failed to ignite charge	
	Axle plates are beginning to show signs of separating.	
		Sight fouled badly from the vent in round 559.
		Barometer, 30.09; thermometer, 89°; humidity, 61.
		Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Chisel used to extract case	
	Chamber sponged out and cleaned. Rope came off right wheel.	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Rope came off right wheel. Chisel used to extract case.	
	Chisel used to extract case.	
	Case used at beginning of firing used in this round. Chisel used to extract case.	
	Rammer used to force block home. Same case used as in previous round.	
	Gun thoroughly cleaned out before this round. New cartridge case used.	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
P.M.			*Ounces.*		*Lbs. Oz.*	° ′	*Right.*	*Feet.*
Aug. 9	583		11	Shell (reamed), with wooden plugs driven in point.	11 2 12 sand. 11 14	8 31	¼	16
Aug. 9	584		11		11 2 12 sand. 11 14	8 33	*Left.* 3	16
Aug. 9	585		11		11 2 12 sand. 11 14	8 36	3	17
Aug. 9	586		11	Shrapnel, lot 294, with Frankford Arsenal point percussion fuse.	11 13 2 11 15 shrapnel and fuse, powder, bursting charge.	8 35	2¼	17

Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.

(*weight 219 pounds*), *at Sandy Hook, N. J., August 9, 1892*—Continued.

gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From right and front, 9 miles an hour.	Sighting shot. Struck 100 yards in front and 25 feet to right of target.	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887. Fired from fort wall, to burst on passing through screen 1 mile from gun. Screen 24 feet high, 39 feet wide, and 1 inch thick; 75 feet in front of first target. Four targets, 6 feet high, 52 feet wide, and 1 inch thick, placed 75 feet apart. Barometer, 30.08; thermometer, 90°; humidity, 65.
	Sighting shot. Struck 100 yards in front of center of target.	
	Sighting shot. Struck screen 11 feet above and 11 feet to left of center.	
	Shrapnel struck, screen 10½ feet left and 11 feet above center, passed through, and burst. Number of hits on target as follows: [First target, 75 feet in rear of screen.] Balls through ..... 21 Balls embedded ..... 0 Balls made mark ..... 2 Fragments through ..... 2 Fragments embedded ..... 1 Fragments made mark ..... 0 Total ..... 26 [Second target, 150 feet in rear of screen.] Balls through ..... 25 Balls embedded ..... 6 Balls made mark ..... 15 Fragments through ..... 1 Fragments embedded ..... 3 Fragments made mark ..... 0 Total ..... 50 [Third target, 225 feet in rear of screen.] Balls through ..... 5 Balls embedded ..... 2 Balls made mark ..... 4 Fragments through ..... 0 Fragments embedded ..... 0 Fragments made mark ..... 0 Total ..... 11 [Fourth target, 300 feet from screen.] Balls through ..... 0 Balls embedded ..... 0 Balls made mark ..... 4 Fragments through ..... 0 Fragments embedded ..... 0 Fragments made mark ..... 1 Total ..... 5 **Total number of hits on four targets.... 92**	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
P. M.			*Ounces.*		*Lbs. Oz.*	° ′	*Left.*	*Feet.*
Aug. 9	587	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Shrapnel, lot 294.	11 13 shrapnel and fuse. 2 powder, bursting charge. 11 15	8 34½	1¾	16
Aug. 11	588		11	Shell (rebanded).	11 4 12 sand. 12 0	8 36	1¾	16½
Aug. 11	589		11	Shell (rebanded).	11 4 12 sand. 12 0	8 38	2¼	.....
Aug. 11	590		11	Shrapnel, lot 294, with Frankford Arsenal point percussion fuse.	11 13 shrapnel and fuse. 3 powder, bursting charge. 12 0	8 38	2¼	.....
Aug. 11	591		11	Shrapnel, lot 294, with Frankford Arsenal point percussion fuse.	11 12½ shrapnel and fuse. 3 powder, bursting charge. 11 15½	8 39	2¼	.....

(weight 219 pounds), at Sandy Hook, N. J., August 9 and 11, 1892.

gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From front, 13 miles an hour.	Shrapnel struck 50 yards in front of center of screen and burst.	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887. Fired from fort wall, to burst on passing through screen 1 mile from gun. Screen, 24 feet high, 39 feet wide, and 1 inch thick; 75 feet in front of first target. Four targets, 6 feet high, 52 feet wide, and 1 inch thick, placed 75 feet apart. Barometer, 30.14; thermometer, 90°; humidity, 65; August 11. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Sighting shot. Struck 100 feet in front and 14 feet right of screen.	
	Sighting shot. Struck screen 3 feet left and 12 feet below center.	
	Shrapnel struck about 150 feet in rear and 6 feet left of target.	
	Shrapnel struck screen 11 feet above and 14 feet left of center, passed through, and burst. Number of hits on targets as follows:	
	[First target, 75 feet in rear of screen.]	
	Balls through 24	
	Balls embedded 1	
	Balls made mark 0	
	Fragments through 1	
	Fragments embedded 0	
	Fragments made mark 0	
	Total 26	
	[Second target, 150 feet in rear of screen.]	
	Balls through 15	
	Balls embedded 3	
	Balls made mark 6	
	Fragments through 2	
	Fragments embedded 0	
	Fragments made mark 1	
	Total 27	
	[Third target, 225 feet in rear of screen.]	
	Balls through 4	
	Balls embedded 2	
	Balls made mark 7	
	Fragments through 1	
	Fragments embedded 0	
	Fragments made mark 0	
	Total 14	
	[Fourth target, 300 feet in rear of screen.]	
	Balls through 2	
	Balls embedded 1	
	Balls made mark 1	
	Fragments through 3	
	Fragments embedded 0	
	Fragments made mark 0	
	Total 7	
	Total number of hits on 4 targets **74**	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
A. M.			*Ounces.*		*Lbs. Oz.*	° ′	′	*Feet.*
Aug. 25	592	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	18
Aug. 25	593		11		12 0	.....	.....	18
Aug. 25	594		11		12 0	.....	.....	17
Aug. 25	595		11		12 0	.....	.....	18
Aug. 25	596		11		12 0	.....	.....	18
Aug. 25	597		11		12 0	.....	.....	19
Aug. 25	598		11		12 0	.....	.....	19
Aug. 25	599		11		12 0	.....	.....	16
Aug. 25	600		11		12 0	.....	.....	18
Aug. 25	601		11		12 0	.....	.....	17
Aug. 25	602		11		12 0	.....	.....	17
Aug. 25	603		11		12 0	.....	.....	18
Aug. 25	604		11		12 0	.....	.....	18
Aug. 25	605		11		12 0	.....	.....	18
Aug. 25	606		11		12 0	.....	.....	20
Aug. 25	607		11		12 0	.....	.....	19
Aug. 25	608		11		12 0	.....	.....	18
Aug. 25	609		11		12 0	.....	.....	18
Aug. 25	610		11		12 0	.....	.....	17
Aug. 25	611		11		12 0	.....	.....	18
Aug. 25	612		11		12 0	.....	.....	19
Aug. 25	613		11		12 0	.....	.....	18
Aug. 25	614		11		12 0	.....	.....	19
Aug. 25	615		11		12 0	.....	.....	20
Aug. 25	616		11		12 0	.....	.....	18
Aug. 25	617		11		12 0	.....	.....	19
Aug. 25	618		11		12 0	.....	.....	18
Aug. 25	619		11		12 0	.....	.....	19
Aug. 25	620		11		12 0	.....	.....	18
Aug. 25	621		11		12 0	.....	.....	19
Aug. 25	622		11		12 0	.....	.....	19
Aug. 25	623		11		12 0	.....	.....	18
Aug. 25	624		11		12 0	.....	.....	19
Aug. 25	625		11		12 0	.....	.....	17
Aug. 25	626		11		12 0	.....	.....	18
Aug. 25	627		11		12 0	.....	.....	19
Aug. 25	628		11		12 0	.....	.....	18
Aug. 25	629		11		12 0	.....	.....	19
Aug. 25	630		11		12 0	.....	.....	18
Aug. 25	631		11		12 0	.....	.....	18
Aug. 25	632		11		12 0	.....	.....	18
Aug. 25	633		11		12 0	.....	.....	18
Aug. 25	634		11		12 0	.....	.....	19
Aug. 25	635		11		12 0	.....	.....	19
Aug. 25	636		11		12 0	.....	.....	18
Aug. 25	637		11		12 0	.....	.....	18

(*weight 219 pounds*), *at Sandy Hook, N. J., August 25, 1892.*

gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From left and front, 18 miles an hour.	New cartridge case used	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887. Fired into field butt No. 2. Chamber sponged out after each round. Cartridge case wiped and oiled after each round. The same cartridge case used in rounds 592 to 602, inclusive. The same cartridge case used in rounds 603 to 625, inclusive. The same cartridge case used in rounds 626 to 637, inclusive. Barometer, 30.01; thermometer, 77°; humidity, 91. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	First primer exploded, but failed to ignite charge. Chisel used to extract case.	
	Chisel used to extract case.	
	Rammer used to force breechblock home. First primer exploded, but failed to ignite charge. Chisel used to extract case.	
	Two primers exploded, but failed to ignite charge. Chisel used to extract case.	
	First primer exploded, but failed to ignite charge.	
	Three primers exploded, but failed to ignite charge, owing to residue in bottom of cartridge case. Case removed and new case inserted.	
	Chisel used to extract case.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Chisel used to extract case.	
	First primer exploded, but failed to ignite charge.	
	Rammer used to force breechblock home.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Rammer used to force breechblock home.	
	Rammer used to force breechblock home.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Rammer used to force breechblock home.	
	Rammer used to force breechblock home.	
	First primer exploded, but failed to ignite charge.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	New case used	
	Chisel used to extract case.	
	Chisel used to extract case.	
	First primer failed to ignite charge. Chisel used to extract case.	
	Rammer used to force breechblock home.	
	Rammer used to force breechblock home.	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to determine

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.	Deflection points.	Recoil.
P. M. Aug. 29	638	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	*Ounces.* 11	Shell (rebanded).	*Lbs. Oz.* 11 4 11 sand. 11 15	° ′ 19 28	*Left.* 3	*Feet.* 16
Aug. 29	639		11		11 4 11 sand. 11 15	19 32	6	16
Aug. 29	640		11		11 4 11 sand. 11 15	19 37	7½	16½
Aug. 29	641		11		11 4 11 sand. 11 15	19 34	7½	17
Aug. 29	642		11		11 4 11 sand. 11 15	19 32	7¾	16½
Aug. 29	643		11	Shrapnel, lot 294, with Frankford Arsenal point percussion fuse.	11 6 including nose plug.	19 28	6½	16
Aug. 29	644		11		11 13 including fuse. 2 powder, bursting charge. 11 15	19 29	6	16
Aug. 29	645		11		11 13 including fuse. 2 powder, bursting charge. 11 15	° ′ ″ 19 27 40	6	16

[Object of firing, to test

Aug.	646	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Shrapnel, lot 294, with wooden plug driven in point.	11 0 3 sand. 11 3	4 21	1½	.....
Aug. 29	647		11		11 0 3 sand. 11 3	4 24	1½	.....
Aug. 29	648		11		11 6 3 sand. 11 9	4 24	1½	.....
Aug. 29	649		11		11 6 3 sand. 11 9	4 24	1½	.....

(*weight 219 pounds*), *at Sandy Hook, N. J., August 29, 1892.*

maximum range of effectiveness of shrapnel.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From right and front, 12 miles an hour.	Sighting shot. Struck 100 feet in front and 35 yards to the right of target.	
	Sighting shot. Struck 75 feet in front and 15 feet to the right of target.	
	Sighting shot. Struck 200 yards in rear of target..	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887. Fired to burst on passing through screen 3,000 yards from gun.
	Sighting shot. Struck 300 yards in rear of target..	Screen 30 feet high, 39 feet wide, and 1 inch thick; 60 feet in front of first target. Five targets, 6 feet high, 52 feet wide, and 1 inch thick, placed 60 feet apart.
	Sighting shot. Struck 150 yards in rear and 8 yards to the left of target.	Barometer, 30.24; thermometer, 75°; humidity, 62. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Shrapnel struck 220 yards in rear and little to the left of target. Shrapnel struck 150 yards in rear of the center of target and burst.	
	Shrapnel struck 100 yards in rear of target and burst.	

accuracy of shrapnel.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From right and front, 12 miles an hour.	Sighting shot. Struck 130 yards in front and 2 feet left of center of target.	Cannon friction primers. Fired at 1,000-yards target, from platform near 10-inch carriage.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
.....	3	.....	3	.....	2.34	.....	2.5
2	.....	.....	.....	2.66	.....	.5	.....
.....	1	1.5	.....	.....	.34	2.0	.....

Center of impact: Feet.
Below ..... .66
Left 5
Mean vertical deviation from center of impact..... 1.78
Mean horizontal deviation from center of impact..... 1.666
Mean deviation from center of impact..... 2.438
Barometer, 30.24; thermometer, 75°; humidity, 62.
Gun sighted by Lieut. F. P. Peck, Ordnance Department.
Target observed by H. V. Murphy.
Firing conducted by Lieut. F. P. Peck, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.
		Kind.	Weight.	Kind.	Weight.			
A. M.			*Ounces.*		*Lbs. Oz.*	° ′	*Left.*	*Feet.*
Aug. 30	650	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Shrapnel, lot 294, with wooden plug driven in point.	11 7⅓ 3 sand. 11 10½	4 24	.....	.....
Aug. 30	651		11		11 6 3½ sand. 11 9½	4 24	.....	.....
Aug. 30	652		11		11 6 3½ sand. 11 9½	4 24	.....	.....
Aug. 30	653		11		11 6½ 4 sand. 11 10½	4 24	.....	.....
Aug. 30	654		11		11 6½ 4 sand. 11 10½	4 24	.....	.....
Aug. 30	655		11		11 6½ 3 sand. 11 9½	4 24	.....	.....
Aug. 30	656		11		11 6 3 sand. 11 9	4 24	.....	.....
Aug. 30	657		11		11 6½ 4 sand. 11 10½	4 24	.....	.....

(*weight 219 pounds*), *at Sandy Hook, N. J., August 30, 1892.*

accuracy of shrapnel.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.									General remarks.
	From center of target.				From center of impact.					
	Vertical.		Horizontal.		Vertical.		Horizontal.			
	Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.		
	Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Feet.*	*Feet.*		
From right and front, 10 miles an hour,	...	5	2	...	...	2	4.916	.....		Fired at 1,000-yards target from platform near 10-inch carriage. Cannon friction primers. French quadrant used. Center of impact: Feet. Below ..... 3 Left ..... 2.916 Mean vertical deviation from center of impact..... 2.33 Mean horizontal deviation from center of impact ..... 4.416 Mean deviation from center of impact..... 4.993 Barometer, 30.21; thermometer, 71°; humidity, 77. Gun sighted by Lieut. F. P. Peck, Ordnance Department. Target observed by Corpl. Burt. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	...	4	....	1	...	1	1,916	.....		
	...	7	3.5	...	...	4	6.416	.....		
	...	...	....	...	...	...	.....	.....	Miss; struck 14 yards in front of target.	
	...	...	....	9	3	...	.....	6.084		
	...	...	....	4	3	...	.....	1.084		
	...	2	....	9	1	...	.....	6.084		
	...	...	....	...	...	...	.....	.....	Miss; struck 15 yards in front of target.	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168 (weight

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Ounces.*		*Lbs. Oz.*	° ″		*Pounds.*	*Feet.*
Sept. 10	658	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	.....	18
Sept. 10	659		11		12 0	.....	.....	.....	18½
Sept. 10	660		11		12 0	.....	.....	.....	18
Sept. 10	661		11		12 0	.....	.....	.....	19
Sept. 10	662		11		12 0	.....	.....	.....	19
Sept. 10	663		11		12 0	.....	.....	.....	22
Sept. 10	664		11		12 0	.....	.....	.....	21
Sept. 10	665		11		12 0	.....	.....	.....	19
Sept. 10	666		11		12 0	.....	.....	.....	18
Sept. 10	667		11		12 0	.....	.....	.....	22
Sept. 10	668		11		12 0	.....	.....	.....	22
Sept. 10	669		11		12 0	.....	.....	.....	19
Sept. 10	670		11		12 0	.....	.....	.....	18
Sept. 10	671		11		12 0	.....	.....	.....	19
Sept. 10	672		11		12 0	.....	.....	.....	18
Sept. 10	673		11		12 0	.....	.....	.....	18½
Sept. 10	674		11		12 0	.....	.....	.....	19
Sept. 10	675		11		12 0	.....	.....	.....	18
Sept. 10	676		11		12 0	.....	.....	.....	20
Sept. 10	677		11		12 0	.....	.....	.....	19
Sept. 10	678		11		12 0	.....	.....	.....	19
Sept. 10	679		11		12 0	.....	.....	.....	20
Sept. 10	680		11		12 0	.....	.....	.....	21
Sept. 10	681		11		12 0	.....	.....	.....	19
Sept. 20	682		11		12 0	.....	.....	.....	18
Sept. 20	683		11		12 0	.....	.....	.....	18
Sept. 20	684		11		12 0	.....	.....	.....	19
Sept. 20	685		11		12 0	.....	.....	.....	20
Sept. 20	686		11		12 0	.....	.....	.....	19
Sept. 20	687		11		12 0	.....	.....	.....	19
Sept. 20	688		11		12 0	.....	.....	.....	19
Sept. 20	689		11		12 0	.....	.....	.....	19
Sept. 20	690		11		12 0	.....	.....	.....	22
Sept. 20	691		11		12 0	.....	.....	.....	18
Sept. 20	692		11		12 0	.....	.....	.....	19
Sept. 20	693		11		12 0	.....	.....	.....	19
Sept. 20	694		11		12 0	.....	.....	.....	19
Sept. 20	695		11		12 0	.....	.....	.....	19
Sept. 20	696		11		12 0	.....	.....	.....	18
Sept. 20	697		11		12 0	.....	.....	.....	19
Sept. 20	698		11		12 0	.....	.....	.....	18
Sept. 20	699		11		12 0	.....	.....	.....	19
Sept. 20	700		11		12 0	.....	.....	.....	20
Sept. 20	701		11		12 0	.....	.....	.....	23
Sept. 20	702		11		12 0	.....	.....	.....	20
Sept. 20	703		11		12 0	.....	.....	.....	20
Sept. 20	704		11		12 0	.....	.....	.....	19
Sept. 20	705		11		12 0	.....	.....	.....	20
Sept. 20	706		11		12 0	.....	.....	.....	19
Sept. 20	707		11		12 0	.....	.....	.....	20
Sept. 20	708		11		12 0	.....	.....	.....	19
Sept. 20	709		11		12 0	.....	.....	.....	20
Sept. 20	710		11		12 0	.....	.....	.....	20
Sept. 20	711		11		12 0	.....	.....	.....	20
Sept. 20	712		11		12 0	.....	.....	.....	19
Sept. 20	713		11		12 0	.....	.....	.....	20
Sept. 20	714		11		12 0	.....	.....	.....	22
Sept. 20	715		11		12 0	.....	.....	.....	21
Sept. 20	716		11		12 0	.....	.....	.....	22
Sept. 20	717		11		12 0	.....	.....	.....	22

219 pounds), at Sandy Hook, N. J., September 10 and 20, 1892.

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From front, 9 miles an hour.	.....	Gun mounted on Hotchkiss mountain gun carriage.
	.....	Cannon friction primers, model 1887; Frankford Arsenal, September, 1890.
	Rammer used to force breechblock home	Fired into field butt No. 2.
	.....	Case oiled and chamber sponged out after each round.
	Left brake came off wheel in recoiling.....	Chisel used to extract case in rounds 660 to 681, inclusive.
	Rammer used to force breechblock home. Left brake came off wheel in recoiling.	One case used throughout this firing.
	.....	Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department.
	.....	Gun star gauged after this firing, September 19, 1892, by Lieut. C. B. Wheeler. Ordnance Department.
	Right brake came off wheel in recoiling	
	Both brakes came off wheel in recoiling	
	First primer exploded, but failed to ignite charge	
	.....	
	.....	
	.....	
	.....	
	.....	
	Right brake came off wheel in recoiling	
	.....	
	Rammer used to force breechblock home.....	
	Right brake came off wheel in recoiling	
	Right brake came off wheel in recoiling	
	.....	
From left and front, 18 miles an hour.	New cartridge case used.....	
	Chisel used to extract case.....	
	Chisel used to extract case.....	
	.....	
	Chisel used to extract case.....	
	Chisel used to extract case.....	
	Chisel used to extract case.....	
	.....	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used.
	.....	Cannon friction primers, model, 1887.
	Chisel used to extract case.....	Fired into field butt No. 2.
	Chisel used to extract case.....	Same cartridge case used in rounds 682 to 698, inclusive.
	Chisel used to extract case.....	Chamber sponged out after each round.
	Chisel used to extract case.....	Cartridge case wiped out and oiled after each round.
	Chisel used to extract case.....	Barometer, 30.40: thermometer, 64°; humidity, 56.
	Chisel used to extract case.....	Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	New cartridge case used.....	
	.....	
	Right brake came off wheel in recoiling	
	Chisel used to extract case.....	
	Rammer used to force breechblock home. Chisel used to extract case.	
	.....	
	Rammer used to force breechblock home. Chisel used to extract case.	
	.....	
	.....	
	.....	
	.....	
	Chisel used to extract case.....	
	Chisel used to extract case.....	
	Rammer used to force breechblock home	
	Before this round breechblock cleaned and oiled. First primer failed to ignite charge. Chisel used to extract case.	
	Chisel used to extract case.....	
	Chisel used to extract case.....	
	Chisel used to extract case.....	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168 (weight

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Ounces.*		*Lbs. Oz.*	° ′	.	*Pounds.*	*Feet.*
Sept. 20	718	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	.....	21
Sept. 20	719		11		12 0	.....	.....	.....	20
Sept. 20	720		11		12 0	.....	.....	.....	20
Sept. 20	721		11		12 0	.....	.....	.....	20
Sept. 20	722		11		12 0	.....	.....	.....	21
Sept. 20	723		11		12 0	.....	.....	.....	20
Sept. 20	724		11		12 0	.....	.....	.....	20
Sept. 20	725		11		12 0	.....	.....	.....	20
Sept. 20	726		11		12 0	.....	.....	.....	21
Sept. 20	727		11		12 0	.....	.....	.....	21
Sept. 20	728		11		12 0	.....	.....	.....	20
Sept. 20	729		11		12 0	.....	.....	.....	20
Sept. 20	730		11		12 0	.....	.....	.....	20
Sept. 20	731		11		12 0	.....	.....	.....	20
Sept. 20	732		11		12 0	.....	.....	.....	19
Sept. 20	733		11		12 0	.....	.....	.....	19
Sept. 20	734		11		12 0	.....	.....	.....	19
Sept. 20	735		11		12 0	.....	.....	.....	20
Sept. 20	736		11		12 0	.....	.....	.....	20
Sept. 20	737		11		12 0	.....	.....	.....	20
Sept. 20	738		11		12 0	.....	.....	.....	20
Sept. 20	739		11		12 0	.....	.....	.....	20
Sept. 20	740		11		12 0	.....	.....	.....	18
Sept. 20	741		11		12 0	.....	.....	.....	20
Sept. 20	742		11		12 0	.....	.....	.....	19
Sept. 20	743		11		12 0	.....	.....	.....	20
Sept. 20	744		11		12 0	.....	.....	.....	20
Sept. 20	745		11		12 0	.....	.....	.....	19
Sept. 20	746		11		12 0	.....	.....	.....	20
Sept. 20	747		11		12 0	.....	.....	.....	19
Sept. 20	748		11		12 0	.....	.....	.....	19
Sept. 20	749		11		12 0	.....	.....	.....	20
Sept. 20	750		11		12 0	.....	.....	.....	19
P. M.									
Sept. 20	751		11		12 0	.....	.....	.....	19
Sept. 20	752		11		12 0	.....	.....	.....	19
Sept. 20	753		11		12 0	.....	.....	.....	18
Sept. 20	754		11		12 0	.....	.....	.....	19
Sept. 20	755		11		12 0	.....	.....	.....	19
Sept. 20	756		11		12 0	.....	.....	.....	20
Sept. 20	757		11		12 0	.....	.....	.....	19
Sept. 20	758		11		12 0	.....	.....	.....	18
Sept. 20	759		11		12 0	.....	.....	.....	19
Sept. 20	760		11		12 0	.....	.....	.....	20
Sept. 20	761		11		12 0	.....	.....	.....	20
Sept. 20	762		11		12 0	.....	.....	.....	19
Sept. 20	763		11		12 0	.....	.....	.....	19
Sept. 20	764		11		12 0	.....	.....	.....	17
Sept. 20	765		11		12 0	.....	.....	.....	20
Oct. 4	766		11		12 0	.....	.....	.....	17
Oct. 4	767		11		12 0	.....	.....	.....	21
Oct. 4	768		11		12 0	.....	.....	.....	19
Oct. 4	769		11		12 0	.....	.....	.....	18
Oct. 4	770		11		12 0	.....	.....	.....	19
Oct. 4	771		11		12 0	.....	.....	.....	18
Oct. 4	772		11		12 0	.....	.....	.....	20
Oct. 4	773		11		12 0	.....	.....	.....	19
Oct. 4	774		11		12 0	.....	.....	.....	19
Oct. 4	775		11		12 0	.....	.....	.....	19
Oct. 4	776		11		12 0	.....	.....	.....	18
Oct. 4	777		11		12 0	.....	.....	.....	19
Oct. 4	778		11		12 0	.....	.....	.....	20
Oct. 4	779		11		12 0	.....	.....	.....	19
Oct. 4	780		11		12 0	.....	.....	.....	19
Oct. 4	781		11		12 0	.....	.....	.....	18
Oct. 4	782		11		12 0	.....	.....	.....	19
Oct. 4	783		11		12 0	.....	.....	.....	18
Oct. 4	784		11		12 0	.....	.....	.....	21
Oct. 4	785		11		12 0	.....	.....	.....	20

219 pounds), at Sandy Hook, N. J., September 20 and October 4, 1892.

test gun for endurance.]

Wind, strength, and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From left and front, 18 miles an hour, a. m. From left and front, 11 miles an hour, p. m.	Chisel used to extract case Chisel used to extract case Chisel used to extract case Thimble on left brake broken off. Chisel used to extract case. Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Rammer used to force breechblock home. Chisel used to extract case. Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case Chisel used to extract case	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Same cartridge case used in rounds 699 to 765, inclusive. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C.B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
From left and front, 11 miles an hour.	Rammer used to force breechblock home. Chisel used to extract case. Chisel used to extract case Chisel used to extract case Same cartridge case used in this round as in first 17 rounds. Two primers failed to ignite charge. Cartridge case removed and case used in previous round inserted. First primer failed to ignite charge	
From left and rear, 12 miles an hour.	New cartridge case used First primer failed to ignite charge. Left brake came off wheel in recoiling. Left brake came off wheel in recoiling Chisel used to extract case Left brake came off wheel in recoiling Chisel used to extract case First primer failed to ignite charge. Chisel used to extract case. Breechblock closed with difficulty. Chisel used to extract case. Rammer used to force breechblock home Rammer used to force breechblock home First primer failed to ignite charge New cartridge case used Two primers failed to ignite charge Chisel used to extract case Rammer used to force breechblock home. Right brake came off wheel in recoiling.	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired into sand bank from plank walk leading to machine shop. Cartridge cases wiped off and oiled after each round. The same case used in rounds 766 to 780, inclusive, and 840 to 844, inclusive. Barometer, 29.68; thermometer, 67°; humidity, 54. Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.

Record of firing with 3-inch Hotchkiss mountain gun, No. 168 (weight

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
P. M.			*Ounces.*		*Lbs. Oz.*	° ′		*Pounds.*	*Feet.*
Oct. 4	786	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	.....	21
Oct. 4	787		11		12 0	.....	.....	.....	22
Oct. 4	788		11		12 0	.....	.....	.....	24
Oct. 4	789		11		12 0	.....	.....	.....	20
Oct. 4	790		11		12 0	.....	.....	.....	19
Oct. 4	791		11		12 0	.....	.....	.....	18
Oct. 4	792		11		12 0	.....	.....	.....	19
Oct. 4	793		11		12 0	.....	.....	.....	24
Oct. 4	794		11		12 0	.....	.....	.....	20
Oct. 4	795		11		12 0	.....	.....	.....	19
Oct. 4	796		11		12 0	.....	.....	.....	19
Oct. 4	797		11		12 0	.....	.....	.....	25
Oct. 4	798		11		12 0	.....	.....	.....	21
Oct. 4	799		11		12 0	.....	.....	.....	19
Oct. 4	800		11		12 0	.....	.....	.....	20
Oct. 4	801		11		12 0	.....	.....	.....	20
Oct. 4	802		11		12 0	.....	.....	.....	24
Oct. 4	803		11		12 0	.....	.....	.....	21
Oct. 4	804		11		12 0	.....	.....	.....	19
Oct. 4	805		11		12 0	.....	.....	.....	20
Oct. 4	806		11		12 0	.....	.....	.....	19
Oct. 4	807		11		12 0	.....	.....	.....	19
Oct. 4	808		11		12 0	.....	.....	.....	19
Oct. 4	809		11		12 0	.....	.....	.....	20
Oct. 4	810		11		12 0	.....	.....	.....	20
Oct. 4	811		11		12 0	.....	.....	.....	20
Oct. 4	812		11		12 0	.....	.....	.....	21
Oct. 4	813		11		12 0	.....	.....	.....	24
Oct. 4	814		11		12 0	.....	.....	.....	19
Oct. 4	815		11		12 0	.....	.....	.....	21
Oct. 4	816		11		12 0	.....	.....	.....	25
Oct. 4	817		11		12 0	.....	.....	.....	19
Oct. 4	818		11		12 0	.....	.....	.....	20
Oct. 4	819		11		12 0	.....	.....	.....	20
Oct. 4	820		11		12 0	.....	.....	.....	19
Oct. 4	821		11		12 0	.....	.....	.....	24
Oct. 4	822		11		12 0	.....	.....	.....	23
Oct. 4	823		11		12 0	.....	.....	.....	20
Oct. 4	824		11		12 0	.....	.....	.....	20
Oct. 4	825		11		12 0	.....	.....	.....	20
Oct. 4	826		11		12 0	.....	.....	.....	21
Oct. 4	827		11		12 0	.....	.....	.....	20
Oct. 4	828		11		12 0	.....	.....	.....	19
Oct. 4	829		11		12 0	.....	.....	.....	21
Oct. 4	830		11		12 0	.....	.....	.....	20
Oct. 4	831		11		12 0	.....	.....	.....	20
Oct. 4	832		11		12 0	.....	.....	.....	20
Oct. 4	833		11		12 0	.....	.....	.....	20
Oct. 4	834		11		12 0	.....	.....	.....	23
Oct. 4	835		11		12 0	.....	.....	.....	21
Oct. 4	836		11		12 0	.....	.....	.....	24
Oct. 4	837		11		12 0	.....	.....	.....	21
Oct. 4	838		11		12 0	.....	.....	.....	22
Oct. 4	839		11		12 0	.....	.....	.....	18
Oct. 4	840		11		12 0	.....	.....	.....	19
Oct. 4	841		11		12 0	.....	.....	.....	20
Oct. 4	842		11		12 0	.....	.....	.....	21
Oct. 4	843		11		12 0	.....	.....	.....	19
Oct. 4	844		11		12 0	.....	.....	.....	20
Oct. 4	845		11		12 0	.....	.....	.....	22

219 pounds), at Sandy Hook, N. J., October 4, 1892—Continued.

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From left and rear, 12 miles an hour.	Rammer used to force breechblock home. Chisel used to extract case.	
	Right brake came off wheel in recoiling. Chisel used to extract case.	
	Right brake came off wheel in recoiling. Hook on brake lashed. Chisel used to extract case.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Rammer used to force breechblock home	
	New case used	
	Right brake came off wheel in recoiling. Hook on brake again lashed.	
	Chisel used to extract case	
	Chisel used to extract case	
	Right brake came off wheel in recoiling	
	Chisel used to extract case	
	Chisel used to extract case	
	Carriage turned completely over in recoiling. Chisel used to extract case.	
	Chisel used to extract case	
	Right brake came off wheel in recoiling	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
		Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used.
	Rammer used to force breechblock home. Chisel used to extract case.	Same case used in rounds 781 to 791, inclusive.
	Rammer used to force breechblock home. Chisel used to extract case.	Spokes of wheels are gradually working loose.
	New case used	Same case used in rounds 792 to 810, inclusive.
	Chisel used to extract case	
	Right brake came off wheel in recoiling. Hook on brake again lashed.	
		Same case used in rounds 811 to 830, inclusive.
	First primer failed to ignite charge	
	Right brake came off wheel in recoiling	Same case used in rounds 831 to 837, inclusive, and rounds 853 to 855, inclusive.
	Chisel used to extract case	Same case used in rounds 838 to 839, inclusive, and 856 to 858, inclusive.
	Left brake came off wheel in recoiling	Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Left brake came off wheel in recoiling	
	Chisel used to extract case	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Chisel used to extract case	
	First primer failed to ignite charge	
	Rammer used to force breechblock home	
	Rammer used to force breechblock home. Left brake came off wheel in recoiling. Chisel used to extract case.	
	Case used in previous firing and resized with buff stick used in this round.	
	Same case used as in previous round	
	Left brake came off wheel in recoiling	
	Chisel used to extract case	
	Rammer used to force breechblock home. Right brake came off wheel in recoiling.	
	Rammer used to force breechblock home	
	Case used in previous firing and resized with buff stick used in this round.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Same case used as in first 15 rounds of this firing. Chisel used to extract case.	
	Rammer used to force breechblock home	
	Rammer used to force breechblock home. First primer failed to ignite charge. Chisel used to extract case.	
	Rammer used to force breechblock home. Chisel used to extract case.	
	Rammer used to force breechblock home	
	New case used	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168 (weight

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
P. M.			*Ounces.*		*Lbs. Oz.*	° ′		*Pounds.*	*Feet.*
Oct. 4	846	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded).	12 0	.....	.....	.....	22
Oct. 4	847		11		12 0	.....	.....	.....	21
Oct. 4	848		11		12 0	.....	.....	.....	23
Oct. 4	849		11		12 0	.....	.....	.....	22
Oct. 4	850		11		12 0	.....	.....	.....	22
Oct. 4	851		11		12 0	.....	.....	.....	26
Oct. 4	852		11		12 0	.....	.....	.....	24
Oct. 4	853		11		12 0	.....	.....	.....	20
Oct. 4	854		11		12 0	.....	.....	.....	21
Oct. 4	855		11		12 0	.....	.....	.....	22
Oct. 4	856		11		12 0	.....	.....	.....	22
Oct. 4	857		11		12 0	.....	.....	.....	27
Oct. 4	858		11		12 0	.....	.....	.....	23
Oct. 4	859		11		12 0	.....	.....	.....	20
Oct. 4	860		11		12 0	.....	.....	.....	22
Oct. 4	861		11		12 0	.....	.....	.....	20
Oct. 4	862		11		12 0	.....	.....	.....	22
Oct. 4	863		11		12 0	.....	.....	.....	21
Oct. 4	864		11		12 0	.....	.....	.....	22
Oct. 4	865		11		12 0	.....	.....	.....	20

[Object of firing, to test accuracy

A. M.									
Oct. 18	866	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Shrapnel, lot 294, weighted up with sand.	11 8	8 35	.....	.....	.....
Oct. 18	867		11		11 8	8 32½	.....	1½	.....
Oct. 18	868		11		11 8	8 25	.....	1½	.....
Oct. 18	869		11		11 8	8 25	.....	1½	.....
Oct. 18	870		11		11 8	8 25	.....	1½	.....
Oct. 18	871		11		11 8	8 25	.....	1½	.....
Oct. 18	872		11		11 8	8 25	.....	1½	.....
Oct. 18	873		11		11 8	8 25	.....	1½	.....
Oct. 18	874		11		11 8	8 25	.....	1½	.....
Oct. 18	875		11		11 8	8 25	.....	1½	.....

219 pounds), at Sandy Hook, N. J., October 4 and 18, 1892.

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From left and rear, 12 miles an hour.	Three primers failed to ignite charge. Case removed and pricked. First primer failed to ignite charge. Chisel used to extract case. Rammer used to force breechblock home. Chisel used to extract case.	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used.
	Case used in previous firing and resized with buff stick used in this round. Right brake came off wheel in recoiling Rammer used to force breechblock home. Chisel used to extract case. Case used in round 831 and resized second time with buff stick used in this round. Chisel used to extract case. Rammer used to force breechblock home Rammer used to force breechblock home. Chisel used to extract case. Case used in round 838 and resized second time with buff stick used in this round. Right brake came off wheel in recoiling Rammer used to force breechblock home	Same case used in rounds 845 to 849, inclusive. Same case used in rounds 850 to 852, inclusive. Same case used in rounds 859 to 865, inclusive.
	Chisel used to extract case	Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C.B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	Rammer used to force breechblock home Right brake came off wheel in recoiling Rammer used to force breechblock home	

of shrapnel at one mile.]

From center of target.				From center of impact.					
Vertical.		Horizontal.		Vertical.		Horizontal.			
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.		
From right and front, 8 miles an hour.									Fired from platform near 10-inch proof carriage. Aimed at center of target.
								Sighting shot. Struck 27 yards to the right and 75 yards in rear of target.	Center of impact: Feet. Below 3.166 Right 1.666
								Sighting shot. Struck 175 yards in rear of target.	Mean vertical deviation from center of impact 5.8886
1		5		4.166		3.333			Mean horizontal deviation from center of impact 4.444
								Miss; struck 3 feet in front of target.	Mean deviation from center of impact 7.3773
1.5		5		4.166		3.333			Barometer, 30.28; thermometer, 61°; humidity, 68.
								Miss; struck 25 feet in front of target.	Gun sighted by Lieut. F. P. Peck, Ordnance Department.
								Miss; struck 25 feet in front of target.	Target observed by Corpl. Burt, Ordnance Detachment.
	12		5		8.833		6.666		Firing conducted by Lieut. F. P. Peck, Ordnance Department, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C.B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
								Miss; struck 75 yards in front of center of target.	
								Miss; struck 80 yards in front of center of target.	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168 (weight 219

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Ounces.*		*Lbs. Oz.*	° ′		*Pounds.*	*Feet.*
Dec. 12	876	Du Pont's I. K. H., lot 55; density, 1.725; granulation, 3,120.	11	Cylindrical shot (rebanded).	12 0	.....	.....	No.5, 10,750	15
P. M.									
Dec. 12	877		11½		12 0	.....	.....	No.5, 12,250	22
Dec. 12	878		12		12 0	.....	.....	No.5, 12,800	22
Dec. 12	879		13		12 0	.....	.....	No.5, 12,800	16
Dec. 12	880		14		12 0	.....	.....	No.5, 14,636	.....
Mar. 8	881	Du Pont's I. K. H., lot 27; density, 1.725; granulation, 2,605.	11	Cylindrical shot (rebanded), most of them with pieces broken off.	12 0	.....	.....	No. 4, 13, 307	18
Mar. 8	882		11		12 0	.....	.....	No. 9, 12, 477	18
Mar. 8	883		11		12 0	.....	.....	No. 4, 13, 500	19
Mar. 8	884		11		12 0	.....	.....	No. 9, 12, 523	19
Mar. 8	885		12		12 0	.....	.....	No. 4, 11, 833	20
Mar. 8	886		13		12 0	.....	.....	No. 9, 12, 409	22
Mar. 8	887		13		12 0	.....	.....	No. 4, 14, 523	24
Mar. 8	888		13		12 0	.....	.....	No. 9, 13, 130	23
Mar. 8	889		13		12 0	.....	.....	No. 4, 14, 863	23
Mar. 8	890		13		12 0	.....	.....	No. 9, 14, 327	23
Mar. 8	891		13		12 0	.....	.....	No. 4, 13, 826	23
Mar. 8	892		13		12 0	.....	.....	.....	23
Mar. 8	893		13		12 0	.....	.....	.....	23
Mar. 8	894		13		12 0	.....	.....	.....	23
Mar. 8	895		13		12 0	.....	.....	.....	23
Mar. 8	896		13		12 0	.....	.....	.....	22
Mar. 8	897		13		12 0	.....	.....	.....	23
Mar. 8	898		13		12 0	.....	.....	.....	23

pounds), at Sandy Hook, N. J., December 12, 1892, and March 8, 1893.

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
		Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired into sand bank from plank walk leading to machine shop. Same cartridge case used in all the rounds. Barometer, 30.62; thermometer, 38°; humidity, 57. Firing conducted by First Lieut. E. St. J. Greble, Second U. S. Artillery, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
From left, 18 miles an hour.	New cartridge case used. First primer failed to ignite charge. Case dented at front end.	
	Right brake came off wheel in recoiling	
	Right brake came off wheel in recoiling	
	Cam-latch screw broken	
	Two shells could not be seated at proper place in bore; third shell inserted. Rammer used against breechblock to force it home. Axle broken off close to the hub of both wheels. One spoke in right wheel split. Crack in left cheek of carriage. Breech mechanism unlocked.	
		Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired into sand bank from plank walk leading to machine shop. Cartridge bag cut and a small portion of the powder sprinkled in the bottom of case. Copper cylinders of 9,000 pounds initial compression and tables of 1890. Before this firing new axle and axle plate made and fitted to carriage. Where there was trouble in closing the breech mechanism it was, as a rule, due to the cartridge bag projecting beyond cartridge case. Barometer, 30.18; thermometer, 45°; humidity, 78. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, U. S. Army, in the presence of the testing board. Present: Lieut. C. B. Wheeler, Ordnance Department.
From rear, 16 miles an hour.	New cartridge case used	
	Rammer used against breechblock to force it home. Two primers exploded, but failed to ignite charge.	
	Cartridge bag cut and a few powder grains put in case. First primer failed to ignite charge. Cartridge bag cut as above.	
	Left brake came off wheel in recoiling	
	Chisel used to extract case	
	Chisel used to extract case	
	Chisel used to extract case	
	New case used; case dented near front end	
	First primer failed to ignite charge	
	Chisel used to extract case	
	Chisel used to extract case	
	Right brake broken	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Ounces.*		*Lbs Oz.*	° ′		*Pounds.*	*Feet.*
Mar. 10	899	Du Pont's I. K. H., lot 55; density, 1.725; granulation, 3,120.	13	Cylindrical shot (rebanded).	12 0	.....	.....	.....	45
Mar. 10	900		13		12 0	.....	.....	.....	40
Mar. 10	901		13		12 0	.....	.....	.....	24
Mar. 10	902		13		12 0	.....	.....	.....	25
Mar. 10	903		13		12 0	.....	.....	.....	25
Mar. 10	904		13		12 0	.....	.....	.....	25
Mar. 10	905		13		12 0	.....	.....	.....	26
Mar. 10	906		13		12 0	.....	.....	.....	24
Mar. 10	907		13		12 0	.....	.....	.....	23
Mar. 10	908		13		12 0	.....	.....	.....	24
Mar. 10	909		13		12 0	.....	.....	.....	24
Mar. 10	910		13		12 0	.....	.....	.....	24
Mar. 10	911		13.		12 0	.....	.....	.....	25
Mar. 10	912		13		12 0	.....	.....	.....	24
Mar. 10	913		13		12 0	.....	.....	.....	24
Mar. 10	914		13		12 0	.....	.....	.....	23
Mar. 10	915		13		12 0	.....	.....	.....	24
Mar. 10	916		13		12 0	.....	.....	.....	24
Mar. 10	917		13		12 0	.....	.....	.....	24
Mar. 10	918		13		12 0	.....	.....	.....	24
Mar. 10	919		13		12 0	.....	.....	.....	23
Mar. 10	920		13		12 0	.....	.....	.....	24
Mar. 10	921		13		12 0	.....	.....	.....	25
Mar. 10	922		13		12 0	.....	.....	.....	23
Mar. 10	923		13		12 0	.....	.....	.....	24
Mar. 10	924		13		12 0	.....	.....	.....	25
Mar. 10	925		13		12 0	.....	.....	.....	24
Mar. 10	926		13		12 0	.....	.....	.....	24
Mar. 10	927		13		12 0	.....	.....	.....	23
Mar. 10	928		13		12 0	.....	.....	.....	24
Mar. 10	929		13		12 0	.....	.....	.....	24
Mar. 10	930		13		12 0	.....	.....	.....	24
Mar. 10	931		13		12 0	.....	.....	.....	26
Mar. 10	932		13		12 0	.....	.....	.....	24
Mar. 10	933		13		12 0	.....	.....	.....	24
Mar. 10	934		13		12 0	.....	.....	.....	23
Mar. 10	935		13		12 0	.....	.....	.....	24
Mar. 10	936		13		12 0	.....	.....	.....	24
Mar. 10	937		13		12 0	.....	.....	.....	23
Mar. 10	938		13		12 0	.....	.....	.....	23
Mar. 10	939		13		12 0	.....	.....	.....	23
Mar. 10	940		13		12 0	.....	.....	.....	24
Mar. 10	941		13		12 0	.....	.....	.....	25
Mar. 10	942		13		12 0	.....	.....	.....	23
Mar. 10	943		13		12 0	.....	.....	.....	24
Mar. 10	944		13		12 0	.....	.....	.....	24
Mar. 10	945		13		12 0	.....	.....	.....	24
Mar. 10	946		13		12 0	.....	.....	.....	24
Mar. 10	947		13		12 0	.....	.....	.....	25
Mar. 10	948		13		12 0	.....	.....	.....	25

(*weight 219 pounds*), *at Sandy Hook, N. J., March 10, 1893.*

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From front, 27 miles an hour.	New cartridge case used	Gun mounted on Hotchkiss mountain gun carriage.
	First primer failed; blew out at head	Cannon friction primers, model 1887; Frankford Arsenal, September, 1890.
	First primer failed; blew out at head	Fired into sand bank from plank walk leading to machine shop.
		After 20 feet of recoil plank walk has a down grade.
	Rammer used to force breechblock home	Sand sprinkled on plank walk after round 900.
	First shot could not be seated at proper place in bore; removed and another shot inserted.	New rope brakes fitted to carriage before firing.
		Cartridge bag cut and a small portion of the powder sprinkled in the bottom of case.
		Barometer, 30.32; thermometer, 37°; humidity, 91.
	Gun hung fire	Firing conducted by First Lieut. E. St. J. Greble, Second U. S. Artillery, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, of Board for Testing Rifled Cannon.
	New cartridge case used. Left brake came off wheel in recoiling.	
	Chisel used to extract case	
	First primer failed; blew out at head	
	Chisel used to extract case	
	Chisel used to extract case	
	Case cut off ¼ inch more than the rest of cases in this firing	
	Chisel used to extract case	
	Chisel used to extract case; rammer used against breechblock to extract case.	
	Rammer used to force breechblock home	
	Chisel used to extract case. Rammer used to force breechblock home.	
	New cartridge case used	
	New cartridge case used. Left brake came off wheel in recoiling.	
	First primer failed; blew out at head	
	Carriage tured over in recoiling	
	Case rammed out	
	Case rammed out	

Record of firing with 3-inch Hotchkiss mountain gun, No. 168

[Object of firing, to

Date.	No of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Pressure per square inch of bore.	Recoil.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Ounces.*		*Lbs. Oz.*	° ′		*Pounds.*	*Feet.*
Mar. 14	949	Du Pont's I. K. H., lot 55; density, 1.725; granulation, 3,120.	13	Cylindrical shot (rebanded).	12 0	.....	.....	.....	22
Mar. 14	950		13		12 0	.....	.....	.....	23
Mar. 14	951		13		12 0	.....	.....	.....	23
Mar. 14	952		13		12 0	.....	.....	.....	23
Mar. 14	953		13		12 0	.....	.....	.....	23
Mar. 14	954		13		12 0	.....	.....	.....	23
Mar. 14	955		13		12 0	.....	.....	.....	22
Mar. 14	956		13		12 0	.....	.....	.....	22
Mar. 14	957		13		12 0	.....	.....	.....	22
Mar. 14	958		13		12 0	.....	.....	.....	22
Mar. 14	959		13		12 0	.....	.....	.....	23
Mar. 14	960		13		12 0	.....	.....	.....	22
Mar. 14	961		13		12 0	.....	.....	.....	23
Mar. 14	962		13		12 0	.....	.....	.....	22
Mar. 14	963		13		12 0	.....	.....	.....	22
Mar. 14	964		13		12 0	.....	.....	.....	23
Mar. 14	965		13		12 0	.....	.....	.....	22
Mar. 14	966		13		12 0	.....	.....	.....	23
Mar. 14	967		13		12 0	.....	.....	.....	22
Mar. 14	968		13		12 0	.....	.....	.....	23
Mar. 14	969		13		12 0	.....	.....	.....	22
Mar. 14	970		13		12 0	.....	.....	.....	23
Mar. 15	971		13		12 0	.....	.....	.....	22
Mar. 15	972		13		12 0	.....	.....	.....	22
Mar. 15	973		13		12 0	.....	.....	.....	22
Mar. 15	974		13		12 0	.....	.....	.....	22
Mar. 15	975		13		12 0	.....	.....	.....	22
Mar. 15	976		13		12 0	.....	.....	.....	23
Mar. 15	977		13		12 0	.....	.....	.....	23
Mar. 15	978		13		12 0	.....	.....	.....	22
Mar. 15	979		13		12 0	.....	.....	.....	22
Mar. 15	980		13		12 0	.....	.....	.....	22
Mar. 15	981		13		12 0	.....	.....	.....	22
Mar. 15	982		13		12 0	.....	.....	.....	22
Mar. 15	983		13		12 0	.....	.....	.....	22
Mar. 15	984		13		12 0	.....	.....	.....	22
Mar. 15	985		13		12 0	.....	.....	.....	22
Mar. 15	986		13		12 0	.....	.....	.....	23
Mar. 15	987		13		12 0	.....	.....	.....	23
Mar. 15	988		13		12 0	.....	.....	.....	23
Mar. 15	989		13		12 0	.....	.....	.....	22
Mar. 15	990		13		12 0	.....	.....	.....	22
Mar. 15	991		13		12 0	.....	.....	.....	21
Mar. 15	992		13		12 0	.....	.....	.....	22
Mar. 15	993		13		12 0	.....	.....	.....	22
Mar. 15	994		13		12 0	.....	.....	.....	22
Mar. 15	995		13		12 0	.....	.....	.....	22
Mar. 15	996		13		12 0	.....	.....	.....	22
Mar. 15	997		13		12 0	.....	.....	.....	22
Mar. 15	998		13		12 0	.....	.....	.....	22
Mar. 15	999		13		12 0	.....	.....	.....	22
Mar. 15	1000		13		12 0	.....	.....	.....	22

(*weight 219 pounds*), *at Sandy Hook, N. J., March 14 and 15, 1893.*

test gun for endurance.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
From front and right, 24 miles an hour.	Two primers failed; blew out at head	Gun mounted on Hotchkiss mountain gun carriage. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired into sand bank from plank walk leading to machine shop. Cartridge bag cut and a small portion of the powder sprinkled in the bottom of case. Brakes worn off nearly through where they come in contact with wheels. Barometer, 30.06; thermometer, 45°; humidity, 85. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department, First Lieut. Second Artillery, U. S. Army.
	First primer failed; blew out at head	
	Rammer used to remove case	
	Rammer used to close breechblock	
	Gun hung fire	
	Rammer used in closing breechblock	
	First primer exploded, but failed to ignite charge	
	Gun hung fire	
	Rammer used in closing breechblock	
	Brakes shortened by taking two turns about wheel	
From left and rear, 30 miles an hour.	First primer failed; blew out at head	Gun mounted on Hotchkiss mountain gun carriage. Rope brakes used. Rope brakes repaired before this firing. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired into sand bank from plank walk leading to machine shop. Time required to fire 30 rounds, 26 minutes and 10 seconds. Three men employed. Barometer, 29.98; thermometer, 33°; humidity, 80. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, U. S. Army, in the presence of the testing board. Present: Capt. F. Heath, Ordnance Department, and Lieut. C. B. Wheeler, Ordnance Department.
	First primer exploded, but failed to ignite charge	
	Rammer used to force block home	
	Rammer used to force block home	

Star gauging of 3-inch Hotchkiss mountain gun, No. 168, at Sandy Hook Proving Ground.

LANDS.

[3-inch ring.]

From muzzle.	After 40 rounds, Nov. 5, 1891.	After 505 rounds, June 11, 1892.	After 681 rounds, Sept. 19, 1892.	After 1,000 rounds, Sept. 30, 1893.	Total increase.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0	2.99	3.002	3.002	3.0025	.0125
1	2.99	3.0015	3.002	3.0020	.0120
2	2.99	3.0015	3.0015	3.0020	.0120
3	2.99	3.0015	3.0015	3.0020	.0120
4	2.99	3.0015	3.0015	3.0020	.0120
5	2.991	3.0015	3.0015	3.0020	.0110
6	2.992	3.002	3.0015	3.0020	.0100
7	2.9925	3.002	3.0015	3.0025	.0100
8	2.993	3.002	3.002	3.0025	.0095
9	2.9935	3.002	3.002	3.0025	.0090
10	2.9935	3.002	3.002	3.0025	.0090
11	2.994	3.002	3.002	3.0025	.0085
12	2.995	3.002	3.002	3.0030	.0080
13	2.996	3.0015	3.002	3.0030	.0070
14	2.996	3.0015	3.002	3.0030	.0070
15	2.996	3.002	3.0025	3.0030	.0070
16	2.9965	3.002	3.0025	3.0030	.0065
17	2.997	3.002	3.0025	3.0030	.0060
18	2.998	3.002	3.0025	3.0030	.0050
19	2.997	3.002	3.003	3.0030	.0060
20	2.998	3.0025	3.003	3.0030	.0050
21	2.998	3.002	3.003	3.0030	.0050
22	2.997	3.003	3.003	3.0030	.0060
23	2.997	3.003	3.003	3.0030	.0060
24	2.9965	3.003	3.003	3.0030	.0065
25	2.996	3.002	3.0025	3.0030	.0070
26	2.9955	3.0025	3.002	3.0025	.0070
27	2.9955	3.0025	3.0025	3.0030	.0075
28	2.996	3.0035	3.003	3.0035	.0075
29	2.998	3.0035	3.004	3.0035	.0055
30	3.000	3.004	3.0045	3.0045	.0045
31	3.0045	3.007	3.007	3.0070	.0025
32	3.007	3.01	3.011	3.0100	.0030
33	3.014	3.016	3.016	3.0160	.0020
34	.....	.....	3.026	.....	.....

APPENDIX 37.

REPORT BY THE ORDNANCE BOARD ON RESULTS OBTAINED BY FIRING CARTRIDGES FOR FIELD GUNS PUT UP IN WATER-PROOF CASES.

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, February 10, 1893.

SIR: The following report of results obtained by firing cartridges for 3.2-inch B. L. rifle, steel, put up in water-proof cases, is respectfully submitted:

These cartridges were put up at the Sandy Hook Proving Ground July 2, 1891, and issued to the following-named posts, located at widely separated points in the United States: St. Francis Barracks, Fla.; Fort Hamilton, N. Y.; Fort Canby, Wash.; Fort Riley, Kans. (3); Kennebec Arsenal, Me.; Washington Barracks, D. C.; Fort Sheridan, Ill.; Fort Sam Houston, Tex.; Fort Adams, R. I., and Presidio of San Francisco, Cal.

A letter of instruction was sent by the Chief of Ordnance to each of the officers to whom the cartridges were issued, as follows:

I am instructed by the Chief of Ordnance to state that directions have been sent to the commanding officer of the Sandy Hook Proving Ground to forward to you 15 cartridges for the 3.2-inch B. L. rifle, provided with a water-proof covering.

The covering is a case and cap of rubber cloth. After the cartridge is placed in the case the cap is put on and cemented to it by water-proof cement. A rip string is gummed to the interior of the case, and when the cartridge is to be used a sharp pull on the string will rip the case open.

It is desired that when these cartridges are received they may be placed in an ammunition chest and packed closely together. The cartridges should at all times remain in the ammunition chest of one of the limbers and left for one year, being examined and repacked about once in two months until the year has elapsed. The cartridges and cases are then to be returned to the commanding officer of the proving ground in order that the powder may be tested for velocity and pressure.

Two points will require special attention:

(1) When the cartridges are closely packed and exposed to heat and moisture will the cases adhere to each other firmly enough to cause the rubber to strip off when the cases are separated?

(2) Do the cases in the course of a year deteriorate sufficiently to cause small cracks to appear throughout the covering of such depth as to destroy the damp-proof properties of the casing?

Will you please report the date of receipt of these cartridges, the mode of packing, and the arrangement of the chest for exposure?

The cartridges having been subjected to the required storage tests for about one year, were returned to the proving ground, where they were fired for velocity and pressure. The results of these firings are given in detail in the record of firing forwarded herewith. A number

of the cartridges were retained at the proving ground, and five were fired each alternate month up to July, 1892, the velocities and pressures being taken. Appended to this report is an abstract of all results obtained by these firings, the mean velocities and pressures being given for each lot tested. In the original test of the powder and with the cartridges, and in all the bimonthly tests at the proving ground, the 3.2-inch projectile, weighing 13 pounds, was used. Through inadvertence two of the lots and a portion of a third received from posts were tested with a 13½-pound projectile. Firings were therefore made using the same powder and projectiles weighing 13 and 13½ pounds, from which were deduced the corrections to be applied to the results obtained with these lots in order to determine the velocities and pressures that would have been obtained had the 13-pound projectiles been used in their test. The record of these firings is forwarded herewith markep Part II. The results so corrected are used in the abstract. They pertain to the lot received from Fort Hamilton, and the first lot from Fort Riley, and part of the lot from San Antonio, Tex.

The results as shown by the record, and more concisely in the abstract, indicate that a decided benefit would result by putting up in water-proof cases the cartridges designed for issue to field batteries. These advantages would probably have been still further emphasized had cartridges made from the same lot of powder and put up without the water-proof cases been stored and tested in the same manner and under the same conditions as the cartridges that were provided with these cases.

Ordnance Office files 3623, and A, B, C, D, E, F, G, H, 1363 C, 1892, are returned herewith.

CLIFTON COMLY,
Major, Ord. Dept., U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Dept., U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Dept., U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(958–'93.)

Summary of tests in 3.2-inch B. L. rifle (steel), of charges of 3 pounds 12 ounces, I. K. H. powder, lot 27, put up in water-proof cases, July 2, 1891, and stored for about one year at various posts.

Date of test.	No. of the gun used.	Number of rounds fired.	Velocity, mean.	Pressure, mean.	Post where stored.	Remarks.
				Pounds.		
July 7, 1891	26	5	1,694	38,058	Sandy Hook Proving Ground.	Standard test lot 27, I. K. H.
Aug. 22, 1891	26	5	1,689	37,131		
Oct. 27, 1891	26	5	1,685	32,638		
Dec. 28, 1891	26	5	1,688	31,468		Put up in water-proof cases.
Mar. 9, 1892	18	5	1,674	32,590		
May 10, 1892	18	5	1,668	34,369		
July 9, 1892	32	5	1,673	34,847		
Jan. 21, 1893	32	5	1,678	35,365		
Dec. 3, 1892	32	15	1,701	36,832	Fort Hamilton, New York Harbor; Light Battery K, First Artillery.	Packed in ammunition chest; changed every two months. Cases not damaged, and did not adhere to each other.
Dec. 3 and 5, 1892.	32	15	1,702	36,761	Fort Riley, Kans.; Light Battery F, Second Artillery.	Packed on end in limber chest 3-inch gun. On march from Fort Leavenworth to Fort Riley from Nov. 7, 1891, to Mar. 28, 1892, exposed to snow and rain. Transferred to 3.2-inch caisson, and kept under cover. Cases do not adhere, and have not deteriorated.
Dec. 5, 1892	32	15	1,704	36,646	Fort Sam Houston, Tex.; Light Battery F, Third Artillery.	Packed closely; exposed to heat and moisture. Do not adhere and have not deteriorated.
Dec. 23, 1892	32	15	1,693	36,179	Fort Canby, Wash.; commanding officer.	No report. Received back at proving ground in good condition.
Dec. 29, 1892	32	15	1,691	35,666	Fort Sheridan, Ill.; Light Battery E, First Artillery.	Packed in 3-inch limber chest, and constantly used in drills and marches. Packed in 3.2-inch chest, and transferred from Fort Riley, Kans., to Fort Sheridan, Ill., and then used in drills, etc. No stripping or cracks and no deterioration.
Dec. 29, 1892	32	15	1,701	36,292	Fort Riley, Kans.; Light Battery A, Second Artillery.	Packed in ammunition chest and kept under cover, except at drills. On march of 325 miles frequently examined and repacked. Cases in as good order as when first packed.
Dec. 29, 1892	32	15	1,696	35,666	Presidio of San Francisco, Cal.; Light Battery F, Fifth Artillery.	Packed in limber chest, and examined every two months. Subject to drills and a march of 200 miles. In perfect condition.
Dec. 30, 1892	32	15	1,709	36,388	Benicia Arsenal, Cal.	Packed in ammunition chest in open ground. Cases do not adhere and in normal condition.
Jan. 7, 1893	32	15	1,680	34,690	Fort Adams, R. I.; Light Battery B, Fourth Artillery.	Packed as directed. Cases do not adhere. When packed tightly to prevent movement, remain intact. Two which were loose the rubber split and cases are useless.
Jan. 9, 1893	32	15	1,699	34,582	Fort Riley, Kans.; Light Battery F, Fourth Artillery.	Packed as directed. Caisson used in drills and marches, and in open gun-shed when not in use; did not adhere, and have not deteriorated.
Jan. 11, 1893	32	15	1,684	34,482	Saint Francis Barracks	No report.
Jan. 13, 1893	32	15	1,691	35,377	Kennebec Arsenal, Me.	Packed in limber, left out of doors; repacked once in two months. In five, water-proof covering at end open 1 to 2 inches, exposing bag; two open where rip string is attached, not enough to expose bag. Cases do not scale or crack. More care required in putting case together.
Jan. 13 and 14, 1893.	32	13	1,686	35,302	Washington Barracks, D. C.	No report.

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet

[Object of firing, to test the

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.
		Kind.	Weight.	Kind.	Weight.		
			Lbs. Oz.		*Lbs. Oz.*	° ′	*Left.*
June 30	672	Du Pont's I. K. H., lot 55; density, 1.725; granulation, 3.120.	3 12	Shell, lot 431.	13 8 including sand.	1 8	1¼
June 30	673		3 12		13 8 including sand.	1 5	1
June 30	674		3 12		13 8 including sand.	1 3	1
June 30	675		3 12	Shrapnel S. H., lot 508; A. P. Co., lot 40.	13 5 shrapnel and fuse. 3 rifle powder, bursting charge. 13 8	1 3	1
June 30	676		3 12	Shell, lot 431.	13 8 including sand.	1 3	1
June 30	677		3 12	Shrapnel S. H., lot 495; A. P. Co., lot 37.	13 5 shrapnel and fuse. 3 rifle powder, bursting charge. 13 8	1 4	1
June 30	678		3 12	Shrapnel S. H., lot 508; A. P. Co., lot 40.	13 5 shrapnel and fuse 3 rifle powder, bursting charge. 13 8	1 7	1¼
							Right.
June 30	679		3 12	Shell, lot 431.	13 8 including sand.	1 8	1
June 30	680		3 12		13 8 including sand.	1 3	1¼
June 30	681		3 12	Shrapnel, lot 494; A. P. Co., lot 36.	13 5 shrapnel and fuse. 3 rifle powder, bursting charge. 13 8	1 3	1¼
July 1	682		3 12	Shell, lot 431.	13 8 including sand.	1 3	1
July 1	683		3 12	Shrapnel, lot 499; A. P. Co., lot 38.	13 5 shrapnel and fuse. 2 rifle powder, bursting charge. 13 8	1 2	

Arsenal, at Sandy Hook, N. J., June 30 and July 1, 1893.

dispersion of electric-welded shrapnel.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Sighting shot. Struck screen 1 foot from top and 6 inches from left edge, and struck target 3 feet above and 14 feet left of center. Sighting shot. Struck screen 3 feet from top and 5 feet from left edge, and target 4½ feet above and 10 feet left of center. Sighting shot. Struck screen 2½ feet from top and 4½ feet from left edge, and struck target 10½ feet left of center. Shrapnel struck screen 4 feet from top and 2½ feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 68 Bullets embedded ..... 1 Bullets made mark ..... 3 Fragments through ..... 18 Fragments embedded ..... 6 Fragments made mark ..... 0 Total ..... 96 Sighting shot. Struck screen 4½ feet from top and 6 feet from left edge, and target 9 feet left of center. Two primers failed to ignite charge. Shrapnel struck screen 6 feet from top, 2½ from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 101 Bullets embedded ..... 2 Bullets made mark ..... 9 Fragments through ..... 12 Fragments embedded ..... 3 Fragments made mark ..... 5 Total ..... 132 Shrapnel struck screen 3 feet from top and 6 feet from right edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 84 Bullets embedded ..... 3 Bullets made mark ..... 5 Fragments through ..... 15 Fragments embedded ..... 4 Fragments made mark ..... 3 Total 114	Gun mounted on Buffington steel field carriage No. 5. Bow-spring brakes. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired from fort wall, to burst on passing through screen placed 115 feet in front of 1,000-yards target, and 10 feet to the left of center. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. Frankford Arsenal sensitive-point percussion fuse used. Barometer, 30.19; thermometer, 78°; humidity, 56.
Sighting shot. Missed screen, struck target 7 feet above and 6 feet right of center. Sighting shot. Struck screen 7½ feet from top and 6 feet from right edge, and target 13 feet right of center. Shrapnel struck screen 7 feet from top and 6 feet from right edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 106 Bullets embedded ..... 2 Bullets made mark ..... 4 Fragments through ..... 22 Fragments embedded ..... 4 Fragments made mark ..... 7 Total ..... 145 Sighting shot. Struck screen 3 feet from top and 6½ feet from right edge, and target 4 feet above and 9 feet right of center. Shrapnel struck screen 8½ feet from top and 2½ feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 129 Bullets embedded ..... 2 Bullets made mark ..... 0 Fragments through ..... 16 Fragments embedded ..... 5 Fragments made mark ..... 1 Total 153	Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired from fort wall, to burst on passing through screen placed 90 feet in front and 10 feet right of center of target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. Frankford Arsenal sensitive-point percussion fuse used. Barometer, 30.19; thermometer, 77°; humidity, 59. Firing conducted by Lieut. F. P. Peck, Ordnance Department.

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet

[Object of firing, to test the

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.
		Kind.	Weight.	Kind.	Weight.		
			Lbs. Oz.		*Lbs. Oz.*	° ′	*Right.*
July 1	684	Du Pont's I. K. H., lot 55; density, 1.725; granulation, 3,120.	3 12	Shrapnel, lot 495; A. P. Co., lot 37.	13 5 shrapnel and fuse. 3 rifle powder, bursting charge. 13 8	1 4	¾
July 14	816		3 12	Shell, lot 431.	13 8 including sand.	1 05	.....
July 14	817		3 12		13 8 including sand.	1 15	.....
July 14	818		3 12		13 8 including sand.	1 08	.....
July 14	819		3 12		13 8 including sand.	1 03	.....
July 14	820		3 12	Electric-welded shrapnel. Lot 513; A. P. Co., lot 42.	13 5½ including fuse. 2½ rifle powder, bursting charge. 13 8	1 07	.....
July 14	821		3 12	Lot 514, A. P. Co., lot 43.	13 5½ including fuse. 2½ rifle powder, bursting charge. 13 8	1 07	.....
July 14	822		3 12	Lot513; A. P.Co., lot 42.	13 5½ including fuse. 2½ rifle powder, bursting charge. 13 8	1 08	.....
July 14	823		3 12	Lot 514; A. P. Co., lot 43.	13 5½ including fuse. 2½ rifle powder, bursting charge. 13 8	1 07	.....

Arsenal, at Sandy Hook, N. J., July 1 and 14, 1893.

dispersion of electric-welded shrapnel.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Shrapnel struck screen 4 feet from top and 2½ feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 125 Bullets embedded ..... 0 Bullet made mark ..... 1 Fragments through ..... 10 Fragments embedded ..... 2 Fragments made mark ..... 14 Total 152	Gun mounted on Buffington steel carriage No. 5. Bow-spring brakes. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired from fort wall, to burst on passing through screen placed 90 feet in front and 10 feet right of center of target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. Frankford Arsenal sensitive-point percussion fuse used. Barometer, 30.19; thermometer, 77°; humidity, 59. Firing conducted by Lieut. F. P. Peck, Ordnance Department.
Sighting shot. Shot passed through screen 7 feet from top and 3 feet from right edge, struck target 3 feet below and 4½ feet to the right of center. Sighting shot. Missed both screen and target and struck 150 yards in rear. Sighting shot. Missed both screen and target and struck about 150 yards in rear. Struck screen 8 feet from top and 2½ feet from left; struck target 4 feet below and 4 feet to the left of center. Shrapnel struck screen 4 feet from top and 3 feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 112 Bullets embedded ..... 1 Bullets made mark ..... 1 Fragments through ..... 24 Fragments embedded ..... 6 Fragments made mark ..... 0 Total ..... 144 Shrapnel struck screen 7 feet from the top and 1 foot from the left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 92 Bullets embedded ..... 3 Bullets made mark ..... 7 Fragments through ..... 15 Fragments embedded ..... 5 Fragments made mark ..... 0 Total ..... 122 Shrapnel just grazed top of screen, struck target 5 feet from top and 2 feet right of center, passed through and burst.	Gun mounted on Buffington steel field carriage No. 5. Bow-spring brakes. Cannon friction primers, model 1887; Frankford Arsenal, September, 1890. Fired at 1,000-yards target. Fired from fort wall, to b rst on passing through screen 115 feet in front of center of target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high and 52 feet wide. Frankford Arsenal sensitive-point percussion fuse. It is noticed that a greater number of hits occur to the right than to the left of the line of fire. Barometer, 30.12; thermometer, 72°; humidity, 69. Firing conducted by Lieut. F. P. Peck, Ordnance Department, assistant proof officer.
Shrapnel struck screen 7 feet from top and 4 feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 96 Bullets embedded ..... 6 Bullets made mark ..... 3 Fragments through ..... 15 Fragments embedded ..... 6 Fragments made mark ..... 7 Total 133	

APPENDIX 38.

ANNUAL REPORT OF CHIEF ORDNANCE OFFICER DEPARTMENT OF THE PLATTE.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
OFFICE OF CHIEF ORDNANCE OFFICER,
Omaha, Nebr., August 31, 1893.

GENERAL: I have the honor to submit the following report of the operations of this office and of the Omaha ordnance depot during the past year:

OMAHA ORDNANCE DEPOT.

The depot is maintained as a reserve of field stores to be used only in cases of emergency. The necessary supplies for the competition at the Bellevue rifle range are kept on hand at the depot and issued when required. The reserve stock consists of field supplies for about 300 infantry and 200 cavalry, and includes about 250,000 rifle ball cartridges, 100,000 carbine ball cartridges, and 1,500 rounds of ammunition for the Hotchkiss mountain gun. Few issues have been made during the past year. On account of the impending change in the caliber of the revolver about 100,000 revolver ball cartridges were issued in order to reduce the stock. The stores on hand are in good order, and could be issued at short notice in case of an emergency.

ORDNANCE STORES.

The reputation of the Department for always furnishing stores of a superior quality has been fully maintained during the year. No complaints of defective materials have been received, though some changes have been suggested. The new equipments that have been sent out for trial from time to time have been faithfully tried, and intelligent and valuable reports have been rendered by line officers.

The intention of the Department to obtain for the Army the latest and best ideas in equipments, tools, etc., as evinced by the many new articles that have been sent out for trial during the year, is, I think, thoroughly appreciated by officers, and such practical tests undoubtedly assist the Department in procuring the best of everything, and conduce to the contentment of troops with our already superior equipment.

HOTCHKISS GUN PACKS.

The defects in the pack outfits for the Hotchkiss mountain gun alluded to in my last report, which were developed by the Pine Ridge campaign, have been remedied at Rock Island Arsenal, and upon my requisition new packs have been issued to the posts of Fort Omaha, Fort Douglas, Fort Niobrara, and Fort D. A. Russell. These will be experimented with during the summer.

COLT'S DOUBLE-ACTION REVOLVER, CALIBER .38.

The new revolver has been issued during the year to all the cavalry in the department except the Indian troop. It is very handsome, convenient, and apparently well made, and a decided improvement over the old caliber (.45). I have been informed that some defects were developed during the recent competition. These will be investigated and a report made as soon as the reports of the range officers are received.

CURB BIT, MODEL 1892.

Twenty of these bits have been ordered issued to each cavalry troop in this department, and will be thoroughly tried during the ensuing year. This bit, designed by Capt. C. W. Whipple, Ordnance Department, was exhaustively experimented with in this department last year, and the present form was evolved from those experiments. It has the proportions prescribed by cavalry experts, and is made for the comfort as well as the control of the horse. Its success is confidently predicted.

HOOF HOOKS.

The simple hoof hook referred to in my last report as having been issued for trial has been reported upon, and has been generally commended by cavalry officers, and I would recommend that it be regularly issued upon approved requisitions.

NEW EQUIPMENTS.

The principal new equipments and tools that have been practically tried in this department during the past year are as follows:

PICKET PINS.

Two new forms of picket pins have been tried. One was forwarded by the attaché of the United States at St. Petersburg, Russia, and is the invention of a Russian, Mr. A. N. Korrigan. It consists of a central pin with wings hinged on either side of the head, which spread when the pin is driven into the ground. Trial showed that it did not hold nearly so firmly as the service pin. It was not recommended for adoption.

The other pin was an alloy of aluminum, and was designed by Lieut. W. C. Brown, First Cavalry, with the very desirable view of lightening the cavalryman's equipment. It was found not to be sufficiently stiff, as the pull of a man on a lariat would bend it, or even a kick with the foot. Further experiment with a view to obtaining a stiffer alloy was recommended.

BLACKSMITH'S RASPS.

Two forms of rasps have been sent out on trial, the Souther farm rasp and the Peeler rasp. Both were found after practical trial to be inferior for all purposes to the service rasp, though excellent tools for certain uses.

The manufacturers of the Peeler rasp, as an outcome of the reports from the field, have made an addition to their tool for the purpose of overcoming the objections to it. The sample has been sent to the headquarters of the Sixth Cavalry for trial and report.

SADDLE ATTACHMENTS.

Twenty saddles with new pattern girth straps, as suggested by Capt. Godfrey, of the Seventh Cavalry, were given a thorough test last season. They were unanimously approved by the officers who tried them, and it has been recommended that they be put on all saddles in future. The straps are so arranged that the girth ring can move on them forward or back, so as to equalize the strain on the straps, no matter what may be the conformation of the horse.

A description of the drawgirth, invented by G. F. Grummet, Marlinton, Va., was examined at this office, and the device was reported as probably unsuited to the cavalry service. It consists of an arrangement by which the girth is temporarily tightened when pressure is put upon the stirrups.

The surefast girth fastening, invented by H. M. Tileston, Kansas City, Mo. This fastening holds the cincha strap very firmly, and has the advantage that the girth can be tightened without dismounting. The cavalry officers who tried this device were not in favor of it, and it was not recommended. Mr. Tileston has since made an improvement on the surefast, and 40 of his girths are now being tried by the Sixth and Ninth cavalry.

INTRENCHING TOOLS.

A variety of intrenching tools have been sent to the department for trial during the year.

Babcock spade-hatchet. An excellent camp tool, combining spade, hatchet, and hammer, but rather heavy, weighing 2 pounds 4 ounces. It was invented by Maj. J. B. Babcock, assistant adjutant-general. I have suggested that it be tried in competition with a lighter tool.

Luther intrenching tool. A combined shovel and pick, invented by Martin A. Luther, Baker City, Oreg. This tool has a folding blade and a small pick which folds into the back. The tool was considered too weak for service.

Patterson intrenching tool. A combined shovel, hoe, and pick, the hoe and pick forced by revolving the shovel about a pin parallel to the plane of its surface, invented by Maj. J. H. Patterson, Third Infantry. This tool was tried at Fort Omaha and broke under trial. The method of fastening the tool in its several positions was also very defective. It was not recommended in its present form.

Kahan intrenching tool, combining shovel, hatchet, and pick, the two latter formed by revolving the shovel about a pin perpendicular to the plane of its surface. This tool is the invention of Private Joseph Kahan, Company B, Second Infantry, and is now being practically tried by the Seventeenth Infantry at Fort D. A. Russell, Wyo.

ENGLISH CAVALRY SABER.

An English cavalry saber was sent to this department for trial, and was critically examined and tested by the officers of the Sixth Cavalry. They pronounced it too heavy and cumbersome for our service. It was again sent here with the English service saber belt and saddle strap. It is now being experimented with by the Ninth Cavalry.

DODGE BLANKET-ROLL SUPPORT.

Ten blanket-roll supports were sent to Fort Omaha for trial. This device, the invention of Lieut. Charles Dodge, jr., Twenty-fourth

Infantry, is intended as a substitute for the knapsack, and consists of a bent wood yoke to which the blanket roll is strapped. The yoke is then carried *en bandoulieré*. The support is to be tried in competition with the blanket bag and Merriam pack.

ARM CHESTS WITH HINGES AND PADLOCKS.

Finding that it was the almost unanimous opinion of company officers that there should be some means of locking arm chests, so that surplus arms could be better protected, I recommended that at least one chest be issued to each organization after the pattern of a chest that I designed some two years ago, of which two were made and issued. The idea was approved, but in order to save expense, hinges, hasps, and padlocks were issued to companies, and they were required to have them put on the chests in their possession.

When the new rifle is sent out I would strongly recommend that arm chests with hinges and locks be issued with the first equipment for each company.

BELGIAN CARBINE SLING.

A sample of this sling was sent to this office for a report as to its merits for use in our service. The carbine is carried in this sling on the trooper's back, muzzle uppermost. It makes a good appearance on parade, but the difficulty of unslinging the carbine quickly, as well as the undesirability of compelling the cavalryman to carry his carbine on long marches, make it unsuitable to our service.

FOUNTAIN CARBINE SCABBARD.

Based upon the reports of cavalry officers and personal experience in hunting, I recommend that the Fountain scabbard be issued with the new carbine when the cavalry is supplied with them. The scabbard is suspended from the saddle and hangs under the trooper's leg (the left leg when the saber is not carried), inclined so that the butt is slightly higher than the muzzle. This is the system almost universally used by cowboys and hunters on the plains. The carbine is completely protected from injury, is not in the way, can be quickly drawn out for use, and is not a source of danger to the man if he is thrown.

INDIVIDUAL GUN RACKS.

Several instances have occurred during the year of small arms being lost from the company gun racks, presumably stolen by men of the company. For instance, when the gun racks are unlocked, a man may be on duty without his arms, his gun being in a rack. Another man can take this gun and dispose of it and his own gun will still be in its place and the theft is not likely to be discovered until the owner needs the stolen gun. I would recommend that individual gun racks be furnished to all permanent posts instead of the racks now issued for twenty rifles or carbines. A simple form of rack could be devised to be fastened to the barrack wall which would be very inexpensive. Of course the locks would have to be reliable and all different, but probably some form of Yale lock could be obtained for a low cost that would answer. Such a system would fix the responsibility for the safety of his piece definitely upon the man to whom it is issued and would prevent much loss.

INSPECTION OF UNSERVICEABLE ORDNANCE STORES.

This subject is of so much importance that I beg leave to quote from a letter I addressed to your office October 13, 1892, and to reiterate the suggestions contained therein.

I would like to invite attention to the present system of inspecting ordnance and ordnance stores, which, it seems to me, is liable to prove detrimental to the interests of the service unless modified. Under date of February 23, 1892, it was ordered by the Secretary of War that all inspections having in view the condemnation of public property, in accordance with paragraph 970 of the Regulations, should, as far as possible, be made by inspectors-general or acting inspectors-general, during stated inspections prescribed by paragraph 954 of the Regulations. It was further ordered that when an emergency required the detail of a special inspector "no officer so detailed should be in any way connected with the department or corps to which the unserviceable property pertains."

The stores manufactured by the Ordnance Department are of so technical a character that it seems to me almost impossible for an officer who has not been on duty at a manufacturing arsenal to be able to decide in all cases whether or not ordnance stores are absolutely worthless. In many cases stores apparently valueless can be repaired or cleaned at an arsenal at a small fraction of their original cost. In other cases parts of an article that is worthless as a whole can be used in the manufacture of new stores. The inspection of small arms, field pieces, and field ammunition (to limit the scope of my remarks to stores used in this military department) often requires expert knowledge and the use of instruments. It seems curious that under these circumstances "no officer in any way connected with the department to which the unserviceable property pertains" should be allowed to inspect. Surely an officer of the department to which the stores belong ought to be the best judge of their serviceability and their value for manufacturing purposes if unfit for service.

Of course, the inspection reports of the acting inspector-general of the Department are referred to this office for examination and criticism, but in the majority of cases the articles are pronounced worthless and destroyed at the time of inspection, and my advice is practically only asked for as to the disposition of a few indestructible articles, such as arms, bayonet scabbards, etc.

A department staff officer to be efficient should visit the posts in his department at least once a year in order to be thoroughly in touch with the line in regard to its wants, to keep himself familiar with the actual use of the stores his department furnishes, and to obtain knowledge of any improvements that are constantly being made by enterprising officers and enlisted men in order to bring them to the notice of his department. At these annual visits such property pertaining to his department as requires inspection should be brought before him.

REWARDS FOR MARKSMEN.

It seems to me that the present system of rewarding good shooting on the part of enlisted men by means of medals is not the best that could be devised. Undoubtedly the man's skill with his rifle is the test of his efficiency as a soldier, all other things being equal, and the possession of this skill obtained by hard practice, temperate habits, etc., should be rewarded, but I would do this in a more substantial way than by means of mere ornamental rewards. The division of enlisted men of the Ordnance and Engineer Departments into first and second class privates has been very successful in procuring the best material and in preventing desertions. At arsenals I have often had half a dozen applications of good men from the line waiting for a vacancy in my detachment, and desertions from arsenals are very infrequent. The extension of this system to the line has been advocated by at least one general officer in an annual report. A first-class private receives $4 per month more than a second class, and the result in an ordnance detachment is that all the second-class privates are on their good behavior in order to be first, and the first are all as anxious to maintain their position and pay. Undoubtedly the pocket is the most sensitive point of the soldier as well as of most other men.

I would suggest that the grade in the company among the privates be made to depend upon the skill of the men with the rifle. Suppose there are fifty privates in a company of infantry. Let the twenty-five who stand highest as marksmen, after shooting for the whole season under a well-regulated system of target practice, be graded as first-class privates and receive $17 per month, but let the position be forfeited by bad behavior, to be determined by the company commander or a court-martial. The result would, I think, be to keep up the waning interest in target practice, reduce desertion, and produce better discipline. At present only nine men in an infantry company can hope to be noncommissioned officers, but under a system where more than half of the company can gain increased pay by merit, none need be discouraged. The men would then be graded in accordance with their value to the service. The present system of issuing medals is expensive and not satisfactory. The men have to leave their posts and are subject to new conditions at the department range, and often the best shots at home lose through ill health or bad luck. Of course, the additional pay would be a large item, but I think the expense of the medals, the great cost of transportation to the competition ranges of officers and men, the value of the ammunition and other stores used at the competitions and other expenses that would be saved, would go a great way toward furnishing the extra pay to the men. I predict that under such a system there would be fewer desertions and a much more efficient army.

Very respectfully, your obedient servant,

J. C. AYRES,
Captain of Ordnance, Chief Ordnance Officer.

The CHIEF OF ORDNANCE, U. S. ARMY.

APPENDIX 39.

FRANKFORD ARSENAL 3.6-INCH SHRAPNEL; DESCRIPTION OF SHRAPNEL; SUMMARY TABLE OF RESULTS OF FIRING TESTS FOR DISPERSION, AND FIRING RECORDS.

(8 plates.)

The shrapnel, exclusive of filling, consists of three parts, viz: Head, body, and base.

THE HEAD.

(See Fig. II A.)

This is made of cast iron, machined on the exterior, and has a screw thread cut around its base, fitting into the forward part of the body. It is bored and threaded to receive the Frankford Arsenal combination fuse. The head contains the powder chamber, which has a capacity of 4 ounces. Its interior surface is lacquered to prevent danger of premature ignition from friction.

THE BODY.

(Figs. I and II B.)

This is made of lap-welded wrought iron or low steel tubing, machined on the exterior and interior to dimensions, and is threaded front and rear to receive the head and base. It is weakened, for fracture, by circular and longitudinal grooves cut on the inside. It contains a charge of 218 balls, 41+ to the pound, 0.5 inch in diameter, made from an alloy of $8\frac{1}{2}$ parts lead and 1 part antimony. These are assembled in the case in circular layers, and held symmetrically in position by cast-iron separators, so called, made as shown in Figs: I and II L, II and IV F and G, and II and VI H, I, I′, and I″.

The separators are intended to prevent excessive lodgment or deformation of the balls under the shock of discharge and increase the effect of explosion by furnishing additional fragments of effective weight.

A separator, Figs. II and VII K, is placed at the bottom, fitting by means of lugs into recesses in the base, by which independent rotation of the charge of balls is prevented.

Two full rings, Figs. II and IV F, are placed in the middle of the charge for strength.

A separator, flat on the upper side, is placed on top of the charge of balls, and against it the head is screwed. (Figs. II and V E.)

THE BASE.

(Figs. II and III C.)

The base is of cast iron, threaded to screw into the cylindrical case. It is so made as to form a support to the copper band to prevent deformation of the case at this point from the shock of discharge.

The band is of copper, shrunk on its seat and forced through a die, by means of which the metal is flowed into the knurlings on the seat, which prevent slipping. (Fig. II D.)

The total weight of the shrapnel exclusive of fuse is 18 pounds 12½ ounces.

The total number of balls and individual pieces in a shrapnel complete is 280.

Respectfully submitted.

FRANK BAKER,
Captain of Ordnance.

Table of maximum and minimum weights and dimensions of the Frankford Arsenal shrapnel for 3.6-inch breech-loading rifle.

Weights and dimensions.		Maximum.	Minimum.
Weight (without fuse or bursting charge)	pounds	18	18
	ounces	12½	10
Total length (without fuse)	inches	9.3	9.2
Length of head (without fuse)	do	3.075	.....
Diameter of body	do	3.58	3.565
Diameter of head at front	do	1.96	.....
Radius of head	do	5.4	.....
Radius of head inside	do	5	.....
Thickness of base	do	.57	.....
Thickness of separators	do	.49	.....
Thickness of top plate	do	.25	.....
Thickness of bottom plate	do	.25	.....
	do	.49	.....
Thickness of walls of powder chamber	do	.4	.....
Thickness of walls of body	do	.205	0.020
Length of ball chamber	do	4.90	.....
Depth of fuse seat to end of thread	do	1.23	.....
Diameter of fuse seat within threads	do	1.18	.....
Threads per inch	do	8	.....
Exterior diameter of band	do	3.705	3.695
Width of band	do	.5	.....
Distance of band from base	do	.75	.....
Diameter of ball	do	.5	.....
Weight of ball (41+ to the pound)	grains	171	.....
Number of balls	do	218	.....
Number of separators	do	58	.....
Total number of pieces	do	280	.....
Weight of fuse	pounds	1	.....
	ounces	¾	.....
Weight of powder charge	do	4	.....
Weight, total, of shrapnel	pounds	20	19
	ounces	1	14

TABLE I.—*Results with six Frankford Arsenal shrapnel, 3.6-inch.*

[Fired to burst on passing through screen placed in front of 1,000-yards target. Nos. 1, 2, and 3 screen 90 feet in front of target. Nos. 4, 5, and 6 screen 115 feet in front of target. Screen 18 feet high, 13 feet wide, and 1 inch thich. Target 18 feet high, 52 feet wide, and 1 inch thich.]

No. of shrapnel.	Point struck from center—				Hits.						
					Balls.			Fragments.			Total.
	Above.	Below.	Right.	Left.	Through.	Embedded.	Indents.	Through.	Embedded.	Indents.	
	Feet.	*Feet.*	*Feet.*	*Feet.*							
1	5	.....	.....	4	197	.....	.....	60	9	3	269
2	4	.....	.....	1	210	.....	.....	74	9	6	299
3	4	.....	.....	.....	208	.....	.....	77	16	11	312
4	2	.....	.....	½	169	6	2	47	19	13	256
5	.....	2	.....	2½	176	2	7	57	18	13	273
6	4	.....	.....	2½	188	.....	1	68	19	11	287
Total	.....	.....	.....	.....	1,148	8	10	383	90	57	1,696

Record of firing with 3.6-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing,

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.	Wind, strength and direction.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Lbs. Oz.*		*Lbs. Oz.*	° ′	*Left.*	*Feet.*	
Jan. 24	2266	Hexagonal U. F., lot 3; density, 1.700; granulation, 123.	4 6	Shrapnel No. 1, steel, lot 432.	18 9 shrapnel. 1 1 nose plug. 7½ sand. 20 1½	.....	.....	4½	.....
Jan. 24	2267		4 6	Shrapnel No. 2, steel, lot 433.	18 13¾ shrapnel. 1 1 nose plug. 6¼ sand. 20 5	.....	.....	4½	.....
Jan. 24	2268		4 6	Shrapnel No. 2, iron, lot 434.	18 13¾ shrapnel. 1 1¼ nose plug. 6½ sand. 20 5½	.....	.....	4½	.....
Jan. 31	2269		4 6		20 1½ including sand.	2 20	1	14½	From right and rear, 8 miles an hour.
Jan. 31	2270		4 6		20 1½ including sand.	2 30	1	15½	
Jan. 31	2271		4 6		20 1½ including sand.	2 42	1	15	
Jan. 31	2272	Sphero-hexagonal U. F., lot 351.	4 6	Shell, lot 3	20 1½ including sand.	2 50	1	15	
Jan. 31	2273		4 6		20 1½ including sand.	2 50	1	15	
Jan. 31	2281		4 6		20 5 including sand.	2 50	1	15½	

Arsenal, at Sandy Hook, N. J., January 24 and 31, 1893.

test of shrapnel.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Recovered whole. Split along body from head to within an inch of rotating band. Very slight marks of rifling on one side near head.	Gun mounted on Buffington steel field carriage No. 1. Bow-spring brakes. Cannon friction primers, model, 1887; Frankford Arsenal, September, 1890. Fired into sand bank 25 feet in front of gun. A 4-inch screen placed 20 feet in front of gun, and 4 feet from this a 1-inch screen to catch fragments, if shrapnel broke up in passing through 4-inch screen. Barometer, 30.23; thermometer, 33°; humidity, 90. Firing conducted by First Lieut. E. St. J. Greble, Second U. S. Artillery.
Broke up in sand. Very slight marks of rifling on one side near head.	
Recovered whole. Very slight marks of rifling on one side near head. No apparent injury to shrapnel.	
Sighting shot. Lost	Gun mounted on Buffington steel field carriage No. 1. Bow-spring brakes. Cannon friction primers, model, 1887. Frankford Arsenal, September, 1890. Fired at 1 mile target + 100 feet (5,380 feet) from fort wall. Scott's sight used. When axis of gun was at 0 Scott's sight read 10′ elevation. The line of sight is 12.08″ from axis. When sight was 1 point left the axis of gun and line of sight were both on left edge of target. One point at 5,380 feet = 4.7 feet about 1″ at 5,380 feet = 1.56 feet nearly, measured vertically on target. Aimed at center of left-hand edge of target. Barometer, 30.44: thermometer, 36°; humidity, 73.
Sighting shot. Struck 95 yards in front of target, and ricocheted through.	
Sighting shot. Struck 460 yards in front of target. Think gun had wrong elevation.	
Sighting shot. Struck the target 7 feet to the left and 6 inches below the center.	
Sighting shot. First primer failed to ignite charge; shot struck center of bull's-eye.	
Sighting shot. Struck the target 4 feet to the left and on the line of center.	

Record of firing with 3.6-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing,

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.	Wind, strength and direction.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Lbs.* *Oz.*		*Lbs.* *Oz.*	° ′	*Left.*	*Feet.*	
Jan. 31	2274	Sphero-hexagonal U. F., lot 3; density, 1.700; granulation, 123.	4 6	No. 1, steel, shrapnel, lot 432.	20 1½ including nose plug.	2 50	1	14½	From right and rear, 8 miles an hour
Jan. 31	2275		4 6		20 1½ including nose plug.	2 55	1	14½	
Jan. 31	2276		4 6		20 2½ including nose plug.	3 00	1	15	
Jan. 31	2277		4 6		20 3½ including nose plug.	3 04	1	14½	
Jan. 31	2278		4 6	No. 2, steel, shrapnel, lot 433.	20 7½ including nose plug.	3 6	1	14	
Jan. 31	2279		4 6		20 6½ including nose plug.	3 2	1	14	
Jan. 31	2280		4 6	No. 2, iron, shrapnel, lot 434.	20 7 including nose plug.	3 00	1	14½	

[Object of firing, to test

A. M.									
May 25	2284	Du Pont's sphero-hexagonal U. F., lot 3; density, 1.700; granulation, 123.	4 6	Shell (re-banded).	20 0 including sand.	1 10	.....	.....	.....
May 25	2285		4 6	Frankford Arsenal shrapnel, lot 476, with sensitive-point percussion fuse.	19 8 shrapnel and fuse. 4 powder, bursting charge. 19 12	1 10	.....	.....	.....
May 25	2286		4 6		19 8 shrapnel and fuse. 4 powder, bursting charge. 19 12	1 9	.....	.....	.....

Arsenal, at Sandy Hook, N. J., January 31 and May 25, 1893.

test of shrapnel.]

From center of target.				From center of impact.				Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.
Vertical.		Horizontal.		Vertical.		Horizontal.		
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
....	....	....	....	.....	.....	.....	.....	Sighting shot. Miss. Shrapnel struck 24 feet in front of target; good line shot.
....	8.0	....	4.0	.....	6.8334	.2916	.....	
....	3.0	....	4.50	.....	1.8334	.....	.2084	
....	1.0	....	6.0	.1666	.....	.....	1.7084	
5.0	....	....	4.0	6.1666	.....	.2916	.....	
3.50	....	....	5.0	4.6666	.....	.....	.7084	
....	3.50	....	2.25	.....	2.3334	2.0416	.....	

[Target reduced to uniform angle of elevation 3° 04′.]

No. of fire.	From center of target.				From center of impact.			
	Vertical.		Horizontal.		Vertical.		Horizontal.	
	Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
2275..	6.04	...	...	4.0	2.79	....	.29	....
2276..	3.24	...	...	4.5	....	.01	....	.21
2277..	....	1.0	...	6.0	....	4.25	....	1.71
2278..	1.88	...	...	4.0	....	1.37	.29	....
2279..	6.62	...	...	5.0	3.37	....	....	.71
2280..	2.74	...	...	2.25	....	.51	2.04	....

Center of impact: Feet.
Above 3.253
Left 4.291
Deviations from center of impact:
Mean vertical 2.05
Mean horizontal ..... .875
Mean 2.421

Gun sighted by First Lieut. E. St. J. Greble, Second U. S. Artillery.
Target observed by Corpl. Thorpe, Ordnance Detachment.
Firing conducted by First Lieut. E.St. J. Greble, Second U. S. Artillery.

Frankford Arsenal shrapnel.]

Sighting shot. Struck screen 4 feet above center and 5 feet from right edge, passed through, and struck target 1 foot above and 2 feet to the right of center.

Shrapnel struck screen 4 feet from top, and 4 feet left of center, passed through, and burst. Number of hits on target as follows:

Bullets through	197
Bullets embedded	0
Bullets made mark	0
Fragments through	60
Fragments embedded	9
Fragments made mark	3
Total	269

Shrapnel struck screen 5 feet from top and 1 foot left of center, passed through, and burst. Number of hits on target as follows:

Bullets through	210
Bullets embedded	0
Bullets made mark	0
Fragments through	74
Fragments embedded	9
Fragments made mark	6
Total	299

Gun mounted on Buffington steel field carriage No. 1. Bow-spring brakes.
Cannon friction primers, model 1887; Frankford Arsenal, September, 1890.
Fired from fort wall, to burst on passing through screen placed 90 feet in front of center of 1,000-yards target.
Screen 18 feet high, 13 feet wide, and 1 inch thick.
Target 18 feet high, 52 feet wide, and 1 inch thick.
Aimed at center of top of screen.
In round 2289 both bolts holding right cap square broken off and gun transferred to carriage No. 18.
Firing conducted by Lieut. F. P. Peck, Ordnance Department, assistant proof officer.

Record of firing with 3.6-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing, to test

Date.	No. of fire.	Powder.		Projectile.		Elevation.	Deflection points.	Recoil.	Wind, strength and direction.
		Kind.	Weight.	Kind.	Weight.				
A. M.			*Lbs. Oz.*		*Lbs. Oz.*	° ′	*Left.*	*Feet.*	
May 26	2287	Du Pont's sphero-hexagonal U. F., lot 3; density, 1.700; granulation, 123.	4 6	Shell (rebanded).	20 0 including sand.	1 8	1	.....	.....
May 26	2288		4 6		20 0 including sand.	1 8	2½	.....	.....
May 26	2289		4 6	Frankford Arsenal shrapnel, lot 476.	19 8 shrapnel and fuse. 4 powder, bursting charge. 19 12	1 8	2½	.....	.....
May 31	2290		4 6	Shell (rebanded).	20 0 including sand.	1 7	.....	.....	.....
May 31	2291		4 6		20 0 including sand.	1 8	.....	.....	.....
May 31	2292		4 6	Frankford Arsenal shrapnel, lot 476, with sensitive-point percussion fuse.	19 15 shrapnel, fuse, and powder bursting charge.	1 8	.....	.....	.....
May 31	2293		4 6		19 15 shrapnel, fuse, and powder bursting charge.	1 8	.....	.....	.....
June 1	2294		4 6	Shell (rebanded).	20 0 including sand.	1 8	1	.....	.....
June 1	2295		4 6	Frankford Arsenal shrapnel, lot 476.	18 8 shrapnel. 1 1 fuse. 5 19 14	1 8	2½	.....	.....

Arsenal, at Sandy Hook, N. J., May 26 and 31 and June 1, 1893.

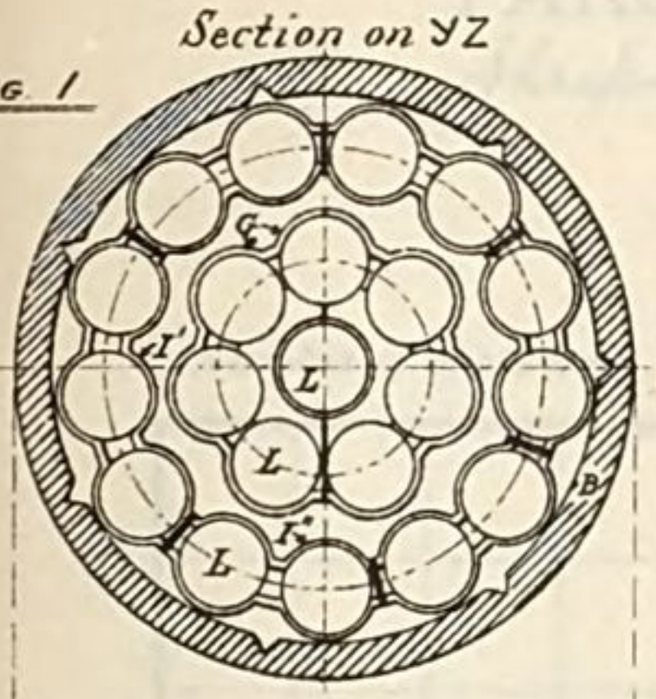
Frankford Arsenal shrapnel.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Before this round screen moved 10 feet to the left. Sighting shot. Missed screen and struck target 1 foot below and 2 feet to the left of center. Sighting shot. Struck screen 5 feet from top and 2½ feet from left edge, passed through, and struck target 13 feet left and 1 foot below center. Shrapnel struck screen 5 feet from top and on line of center, passed through, and burst. Number of hits on targets as follows: Bullets through ..... 208 Bullets embedded ..... 0 Bullets made mark ..... 0 Fragments through ..... 77 Fragments embedded ..... 16 Fragments made mark ..... 11 Total 312	Gun mounted on Buffington steel field carriage No. 1. Bow-spring brakes. Cannon friction primers, model 1887: Frankford Arsenal, September, 1890. Fired from fort wall, to burst on passing through screen placed 90 feet in front of center of 1,000-yards target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. Aimed at center of top of screen. In round 2289 both bolts holding right cap square broken off and gun transferred to carriage No. 18.
Sighting shot. Struck screen 5 feet from right edge and on a line of center, passed through, and struck target 4 feet right and 5 feet below center. Sighting shot. Struck screen 8 feet from top and 5 feet from right edge, passed through, and struck target 4 feet below center. Shrapnel struck screen 7 feet from top and 6 feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 169 Bullets embedded ..... 6 Bullets made mark ..... 2 Fragments through ..... 47 Fragments embedded ..... 19 Fragments made mark ..... 13 Total 256	Cannon friction primers, model 1887: Frankford Arsenal, September, 1890. Fired from fort wall, to burst on passing through screen placed 115 feet in front of center of target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick. Aimed at center of top of screen. Firing conducted by Lieut. F. P. Peck, Ordnance Department, assistant proof officer.
Shrapnel struck screen 11 feet from top and 4 feet from left edge, passed through, and burst. Number of hits on target as follows: Bullets through ..... 176 Bullets embedded ..... 2 Bullets made mark ..... 7 Fragments through ..... 57 Fragments embedded ..... 18 Fragments made mark ..... 13 Total 273	
Sighting shot. Struck screen 5 feet from top and 3 feet from left edge, passed through, and struck target 12 feet left and 2 feet below center. Shrapnel struck screen 5 feet from top and 4 feet from left edge, passed through, and burst. Before this round screen moved 10 feet to the left. Number of hits on target as follows: Bullets through ..... 188 Bullets embedded ..... 0 Bullets made mark ..... 1 Fragments through ..... 68 Fragments embedded ..... 19 Fragments made mark ..... 11 Total 287	

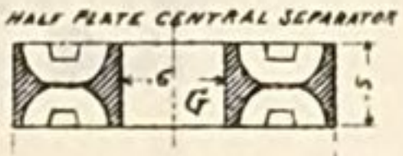
THE FRANKFORD ARSENAL SHRAPNEL FOR 3.6 INCH B.L. RIFLE

Section on YZ

FIG. I



HALF PLATE CENTRAL SEPARATOR



FULL PLATE CENTRAL SEPARATOR

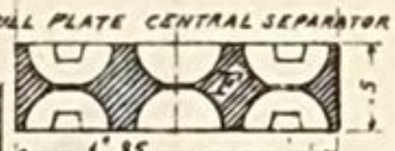
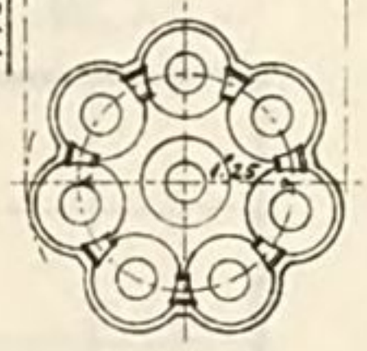


FIG. IV



TOP SEPARATOR

FIG. V

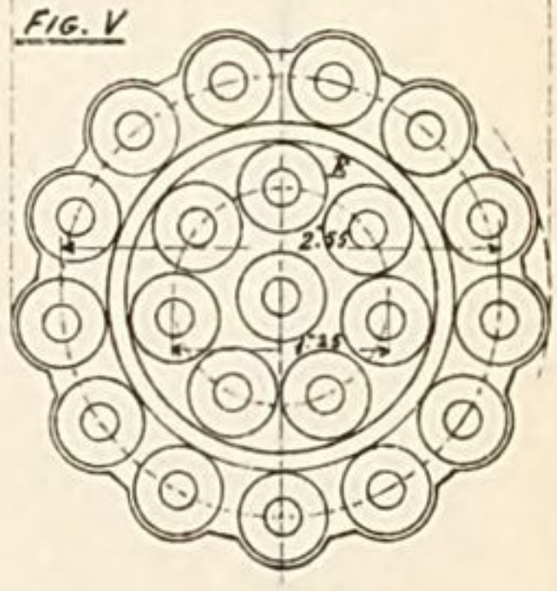
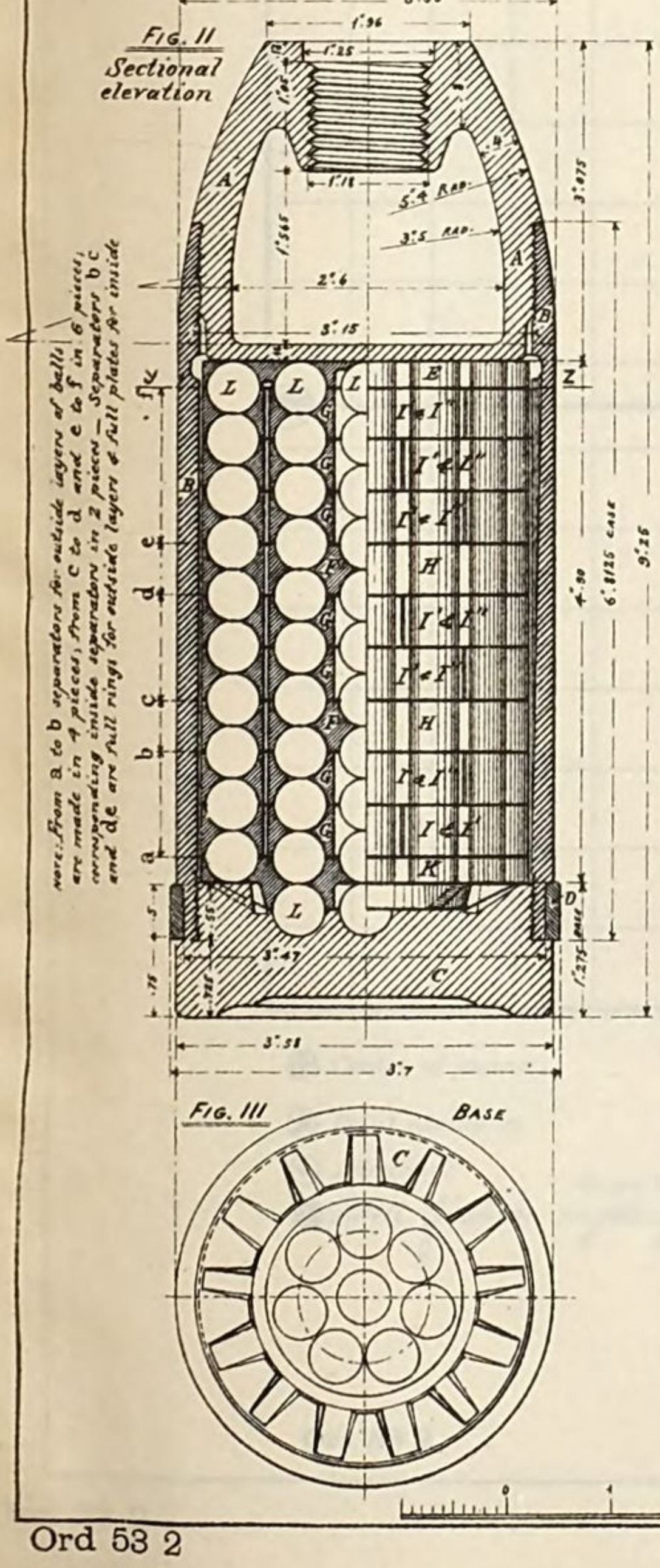


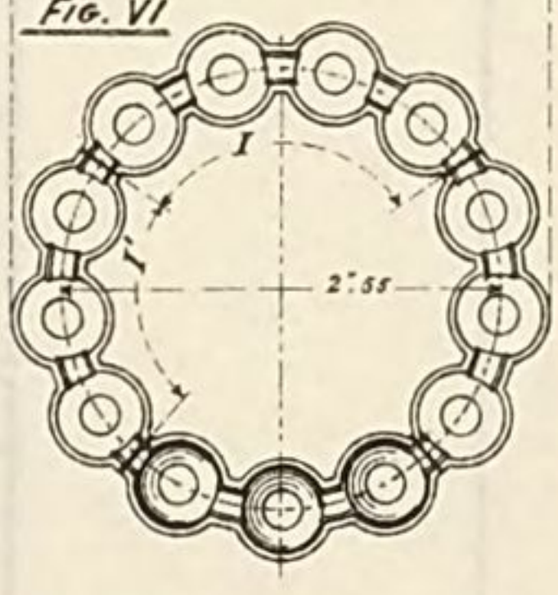
FIG. II
Sectional elevation



note: From a to b separators for outside layers of balls are made in 4 pieces; from c to d and e to f in 6 pieces, corresponding inside separators b c are made in 2 pieces — Separators b c and d e are full rings for outside layers & full plates for inside

OUTSIDE SEPARATOR

FIG. VI



BOTTOM SEPARATOR

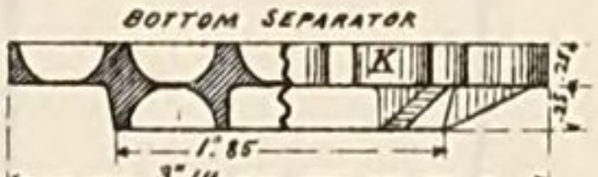
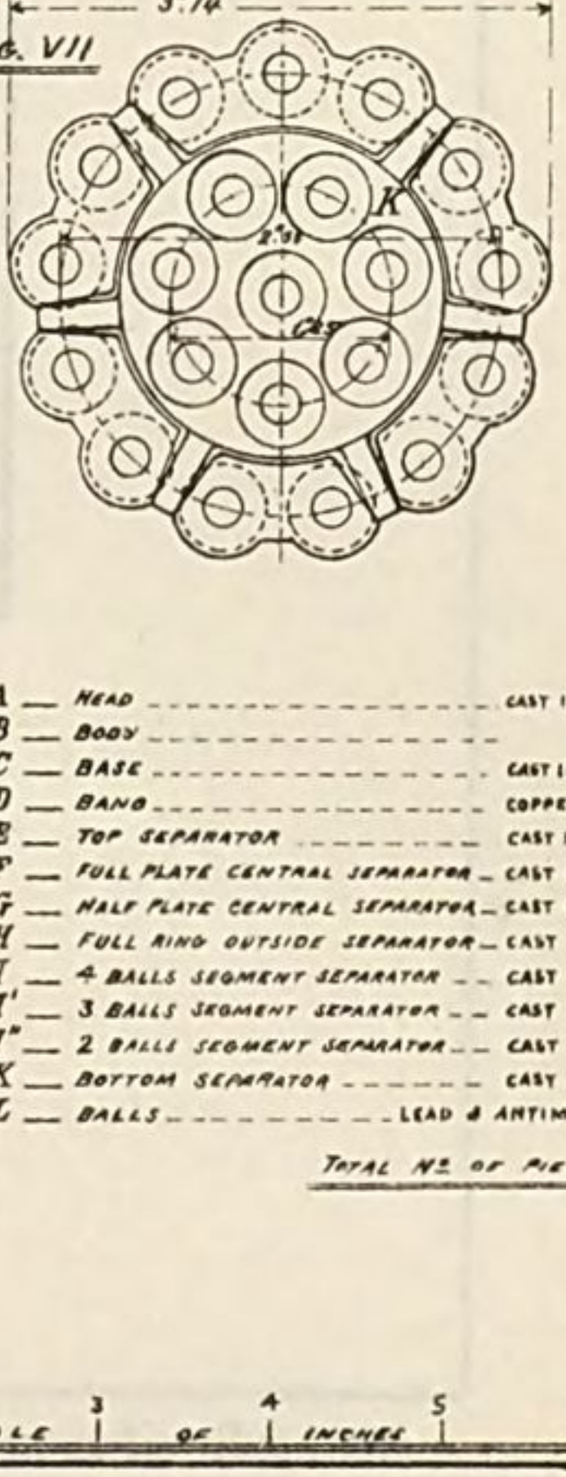


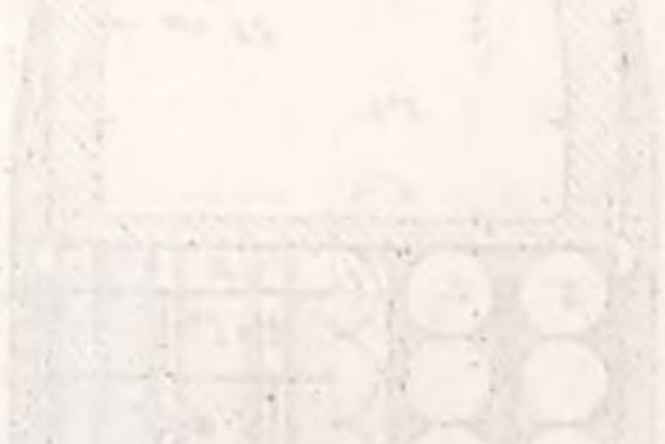
FIG. VII

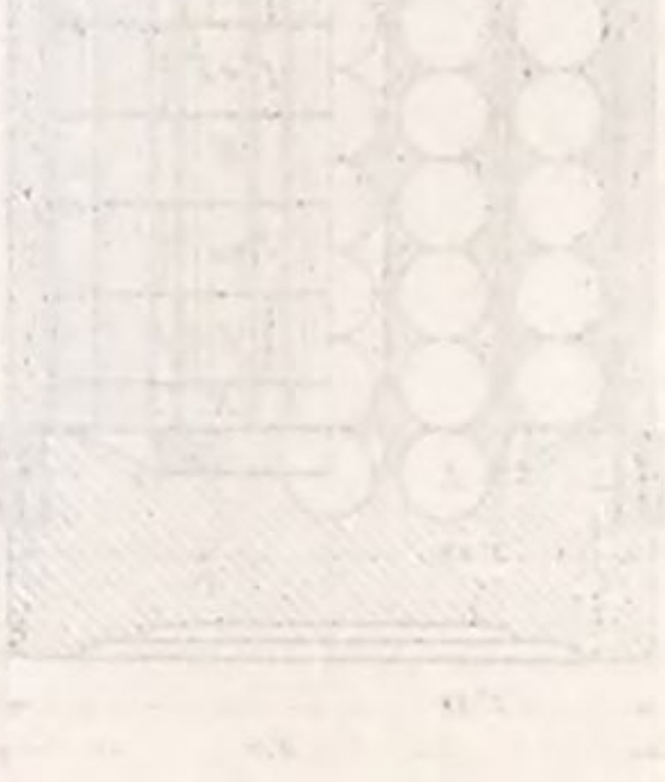


A	HEAD	CAST IRON	Nº of Pieces	1
B	BODY	"	"	1
C	BASE	CAST IRON	"	1
D	BAND	COPPER	"	1
E	TOP SEPARATOR	CAST IRON	"	1
F	FULL PLATE CENTRAL SEPARATOR	CAST IRON	"	2
G	HALF PLATE CENTRAL SEPARATOR	CAST IRON	"	14
H	FULL RING OUTSIDE SEPARATOR	CAST IRON	"	2
I	4 BALLS SEGMENT SEPARATOR	CAST IRON	"	2
I'	3 BALLS SEGMENT SEPARATOR	CAST IRON	"	11
I"	2 BALLS SEGMENT SEPARATOR	CAST IRON	"	25
K	BOTTOM SEPARATOR	CAST IRON	"	1
L	BALLS	LEAD & ANTIMONY	"	218
		TOTAL Nº OF PIECES		280

FIG. III BASE

SCALE OF INCHES 0 1 2 3 4 5 6 7



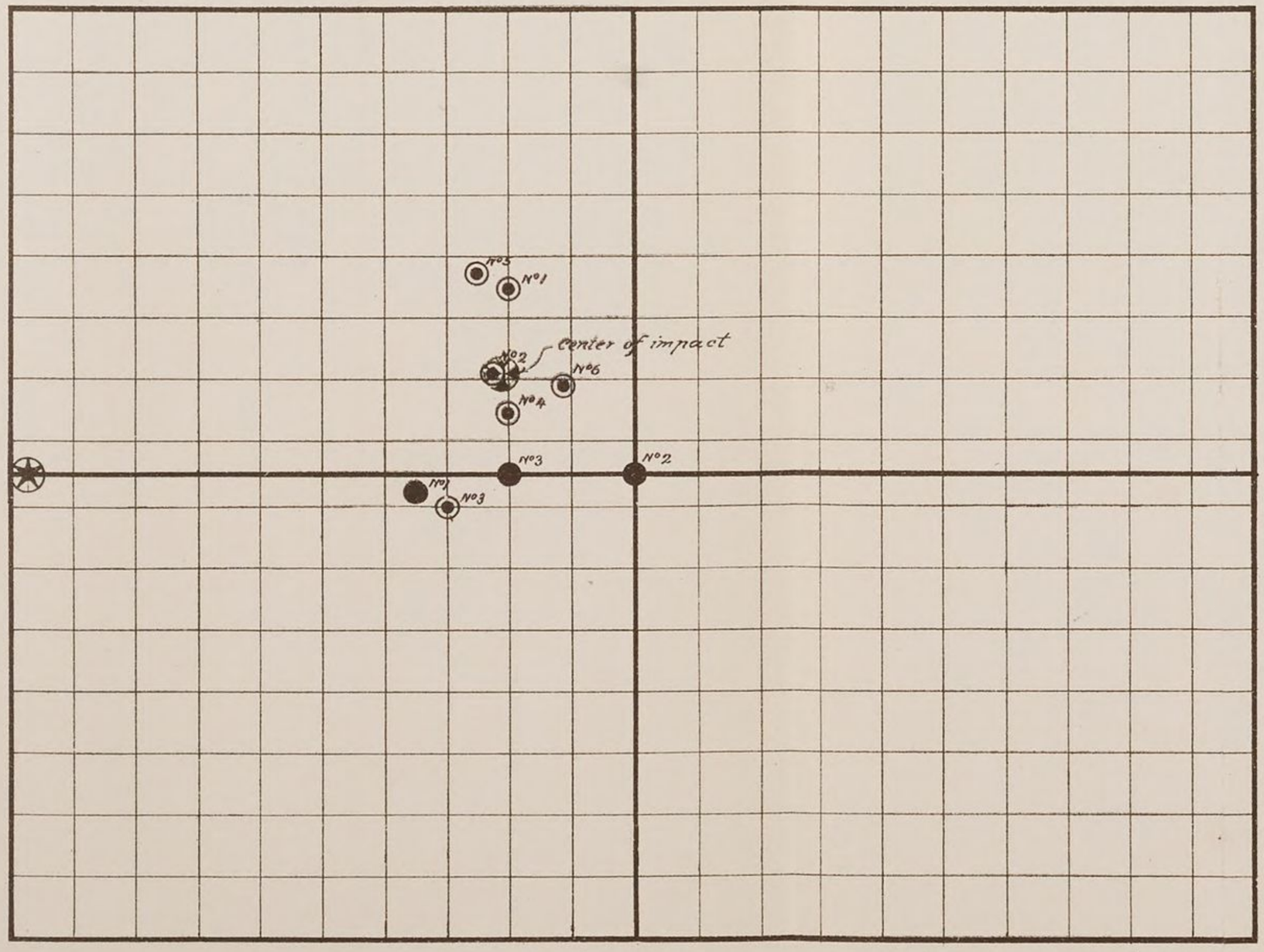


TARGET RECORD of 3.6 B.L. Rifle, Steel. No 1 firing Frankford Arsenal Shrapnel. Reduced to angle of elevation 3°.04'

AT SANDY HOOK, N. J. Jan. 31st 1893.

Target 5380 feet from Gun.

Number of shots fired, 6. Direct hits, 6. Ricochet hits, 0. Misses, 0.



Center of impact.

Point aimed at.

Shrapnel

Shell fired as sighting shots.

Target ~~30 x 40~~ 25' x 39'

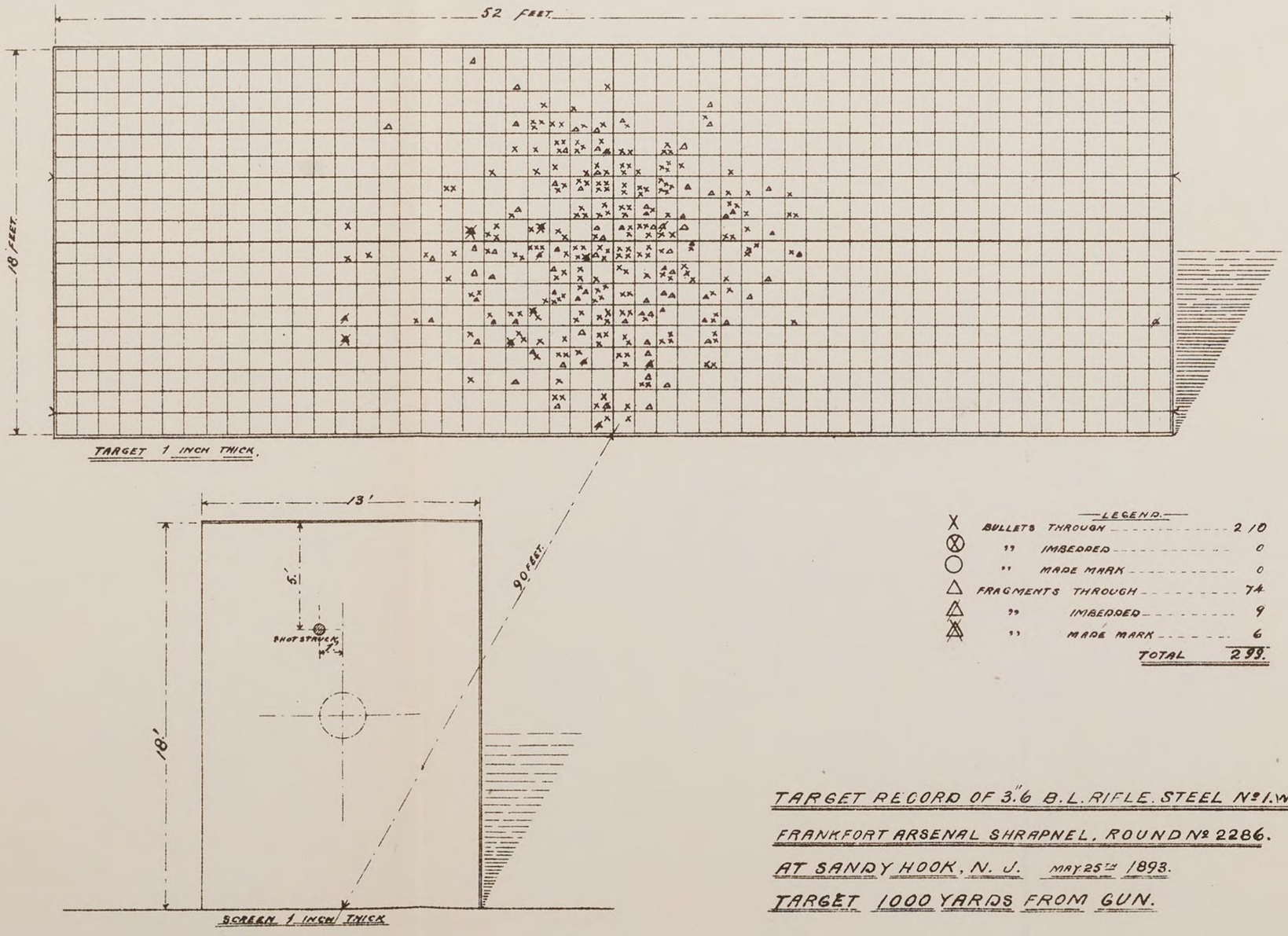
Mean vertical deviation from center of impact, 2.05 feet

Mean horizontal deviation from center of impact, .875 feet

Mean deviation from center of impact, 2.4213 feet

Ord 53 2

Wind 8 miles per hour. from right and rear.



LEGEND.

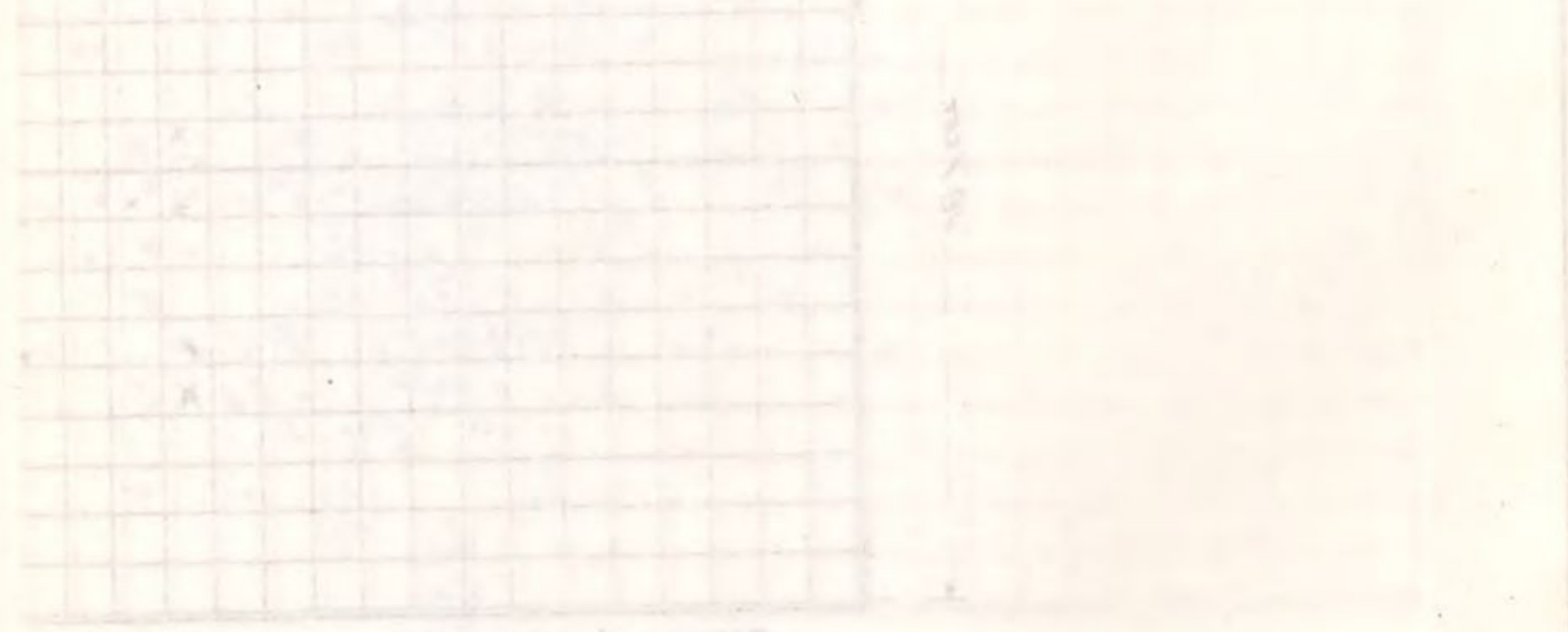
X	BULLETS THROUGH	210
⊗	" IMBEDDED	0
○	" MADE MARK	0
△	FRAGMENTS THROUGH	74
⧋	" IMBEDDED	9
⧋	" MADE MARK	6
	TOTAL	299.

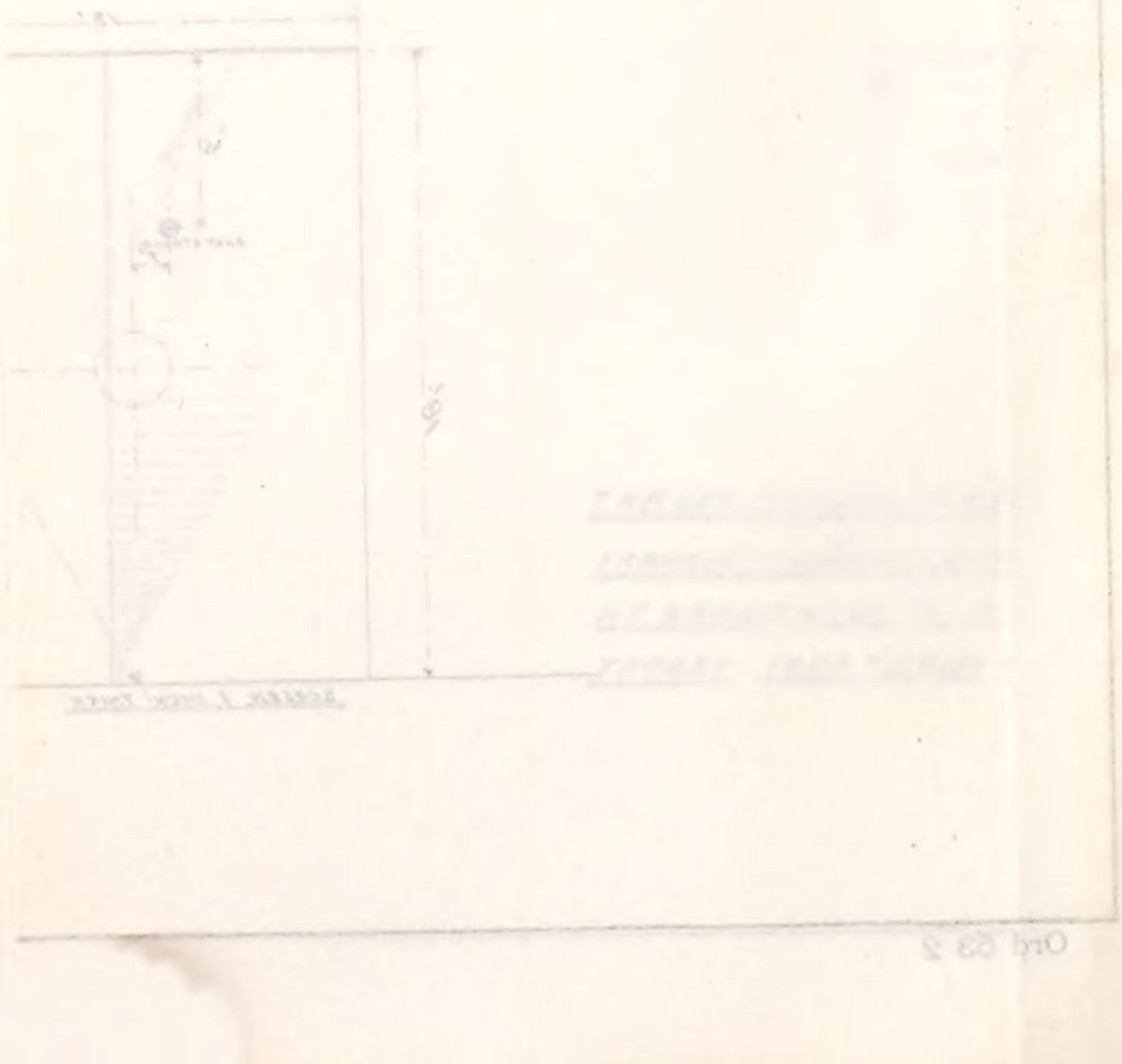
TARGET RECORD OF 3.6 B.L. RIFLE. STEEL No 1. WATERVLIET ARSENAL.

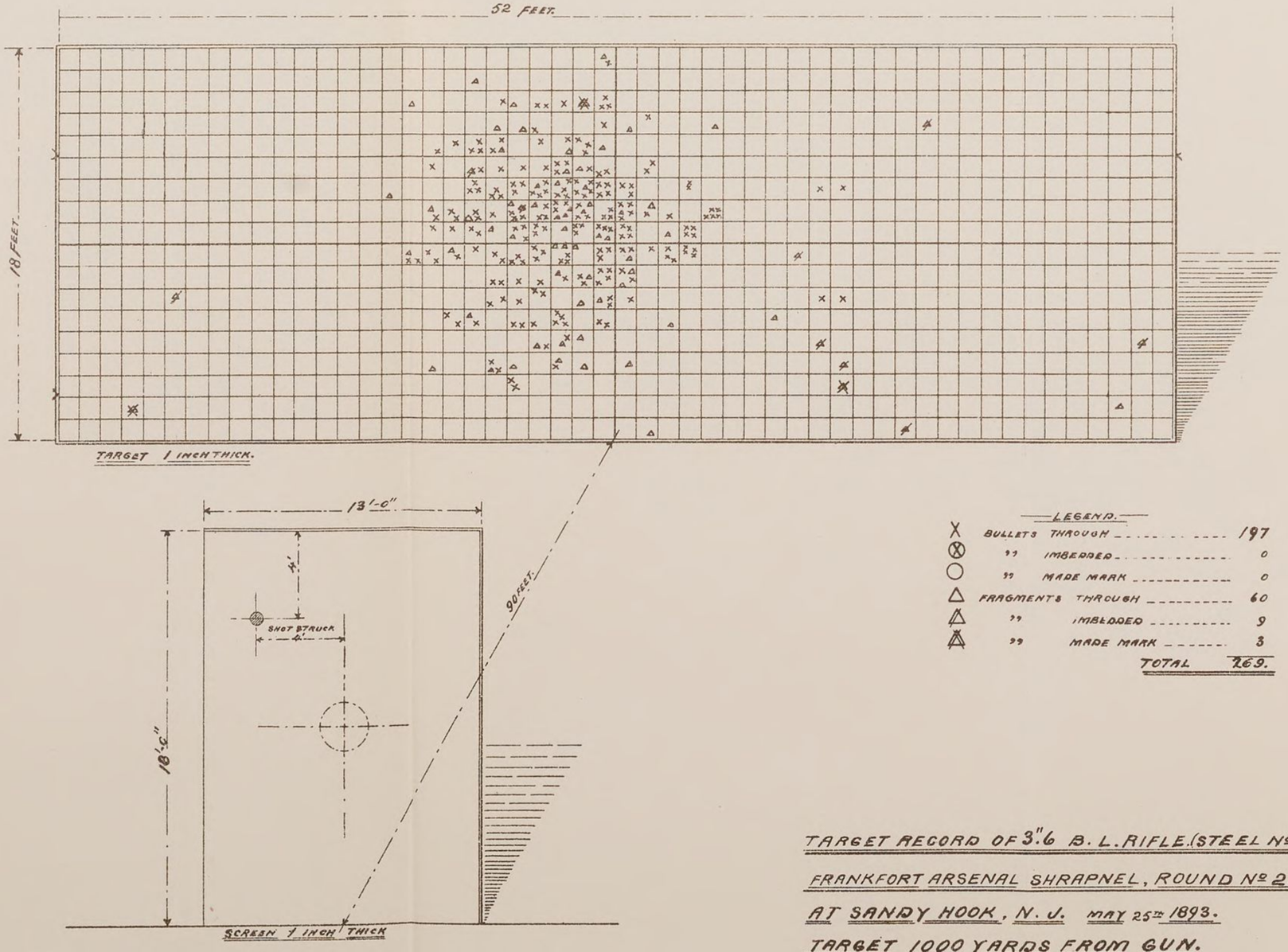
FRANKFORT ARSENAL SHRAPNEL, ROUND No 2286.

AT SANDY HOOK, N. J. MAY 25th 1893.

TARGET 1000 YARDS FROM GUN.







LEGEND.

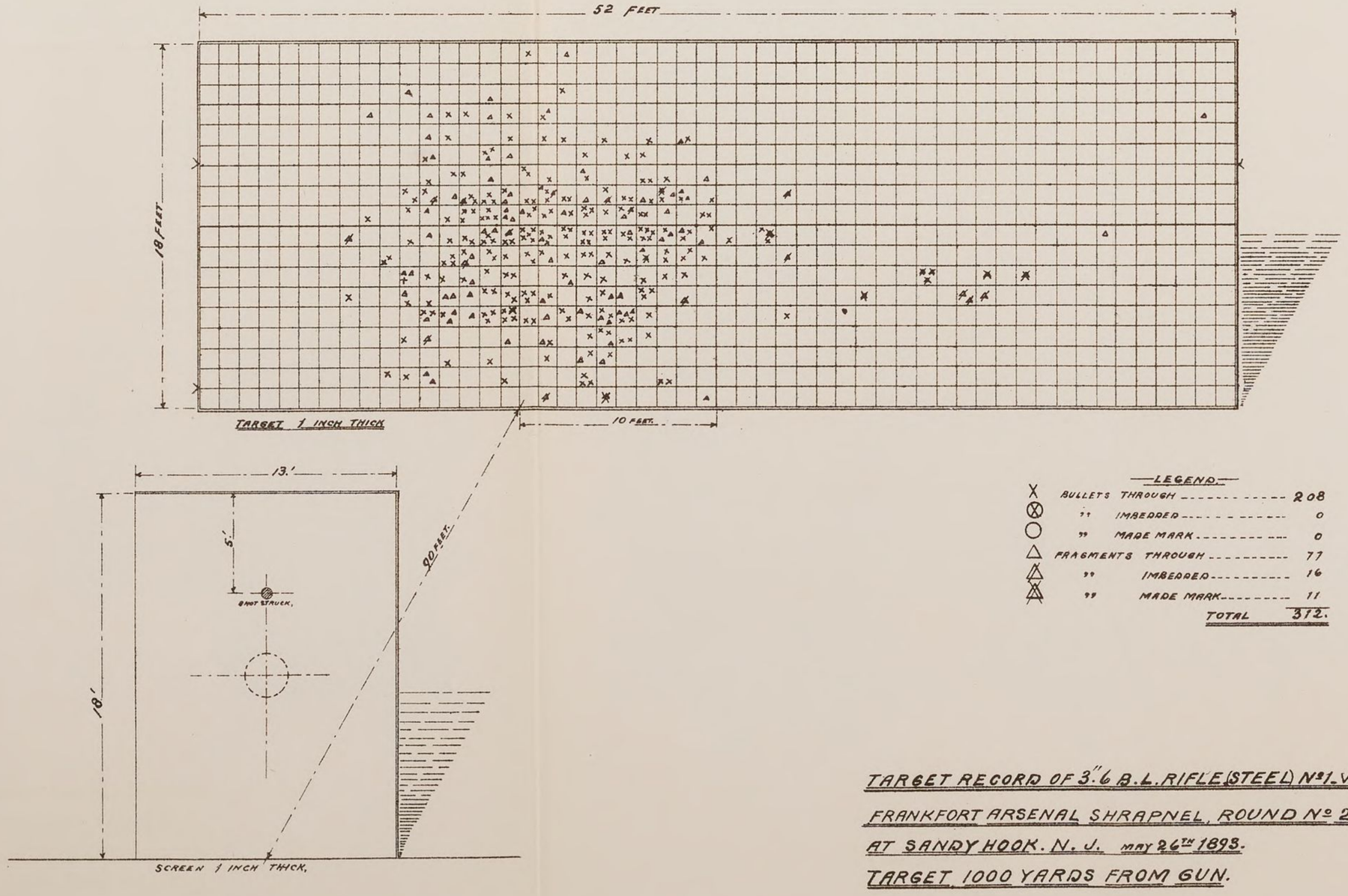
X	BULLETS THROUGH	197
⊗	" IMBEDDED	0
○	" MADE MARK	0
△	FRAGMENTS THROUGH	60
⧋	" IMBEDDED	9
⧋	" MADE MARK	3
	TOTAL	269.

TARGET RECORD OF 3."6 B. L. RIFLE. (STEEL No 1.) WATERVLIET ARSENAL.

FRANKFORT ARSENAL SHRAPNEL, ROUND No 2285.

AT SANDY HOOK, N. J. MAY 25th 1893.

TARGET 1000 YARDS FROM GUN.



LEGEND.

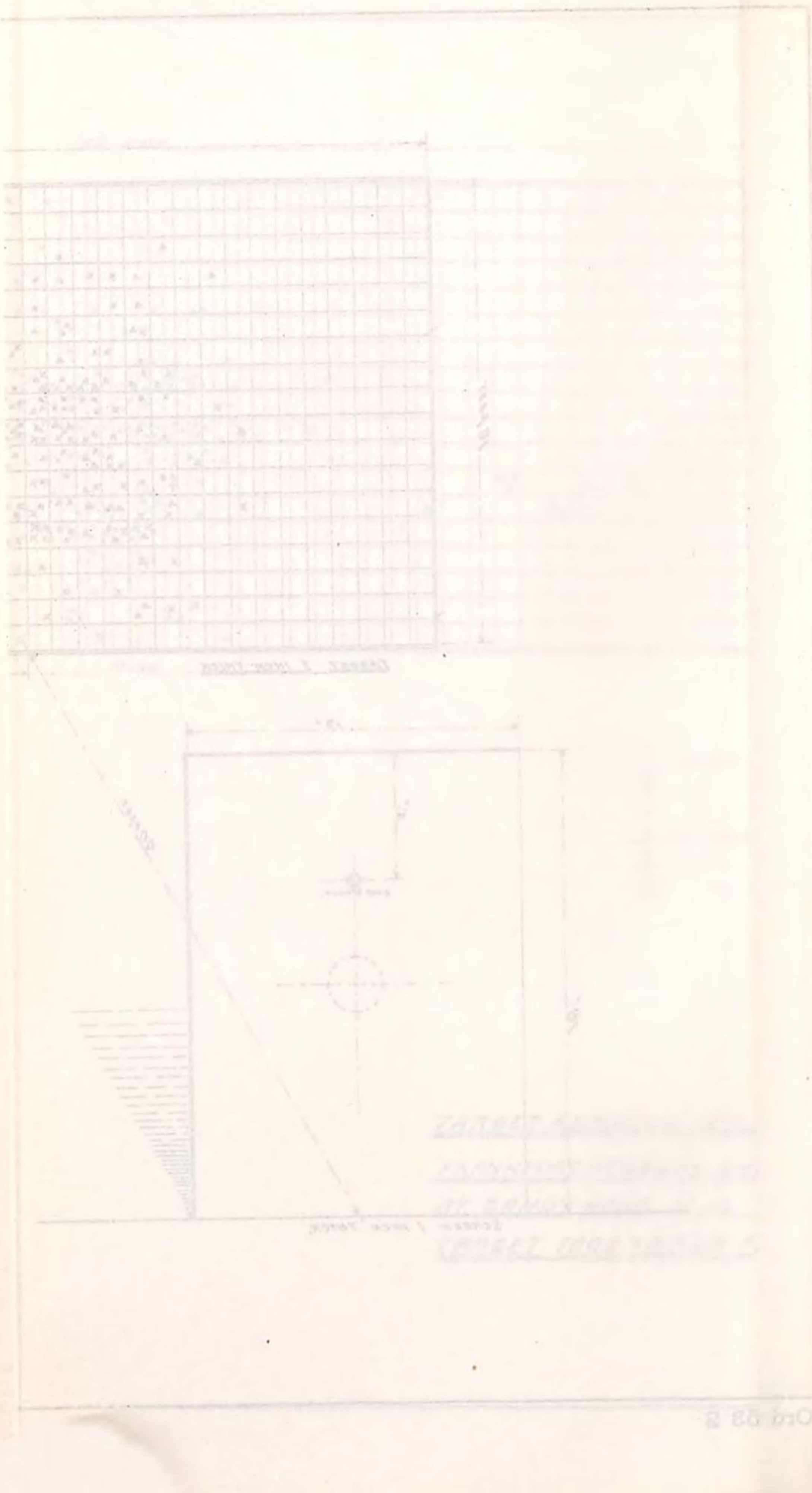
X	BULLETS THROUGH	208
⊗	" IMBEDDED	0
○	" MADE MARK	0
△	FRAGMENTS THROUGH	77
⧋	" IMBEDDED	16
⧋	" MADE MARK	11
	TOTAL	312.

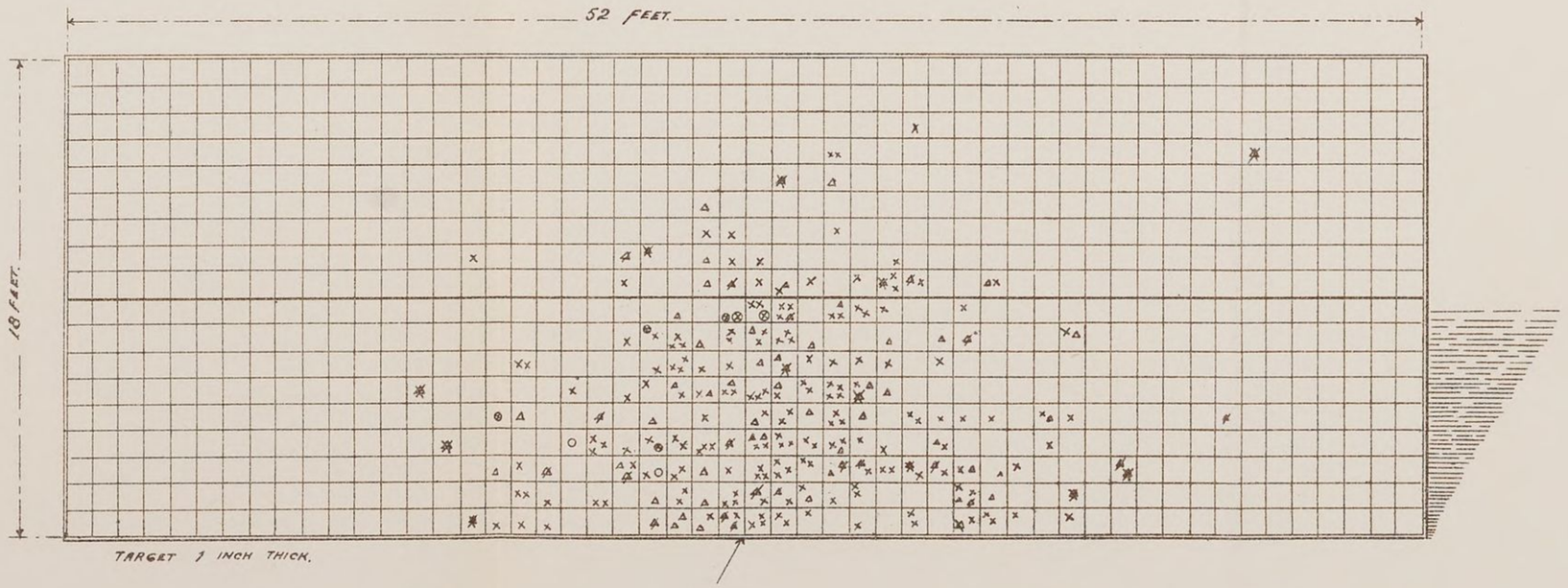
TARGET RECORD OF 3.″6 B.L. RIFLE (STEEL) No 1. WATERVLIET ARSENAL.

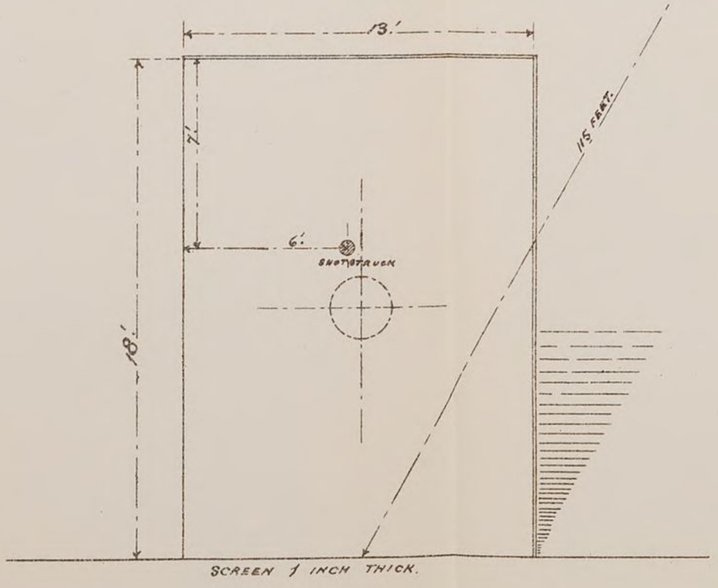
FRANKFORT ARSENAL SHRAPNEL, ROUND No 2289.

AT SANDY HOOK. N. J. MAY 26TH 1893.

TARGET 1000 YARDS FROM GUN.

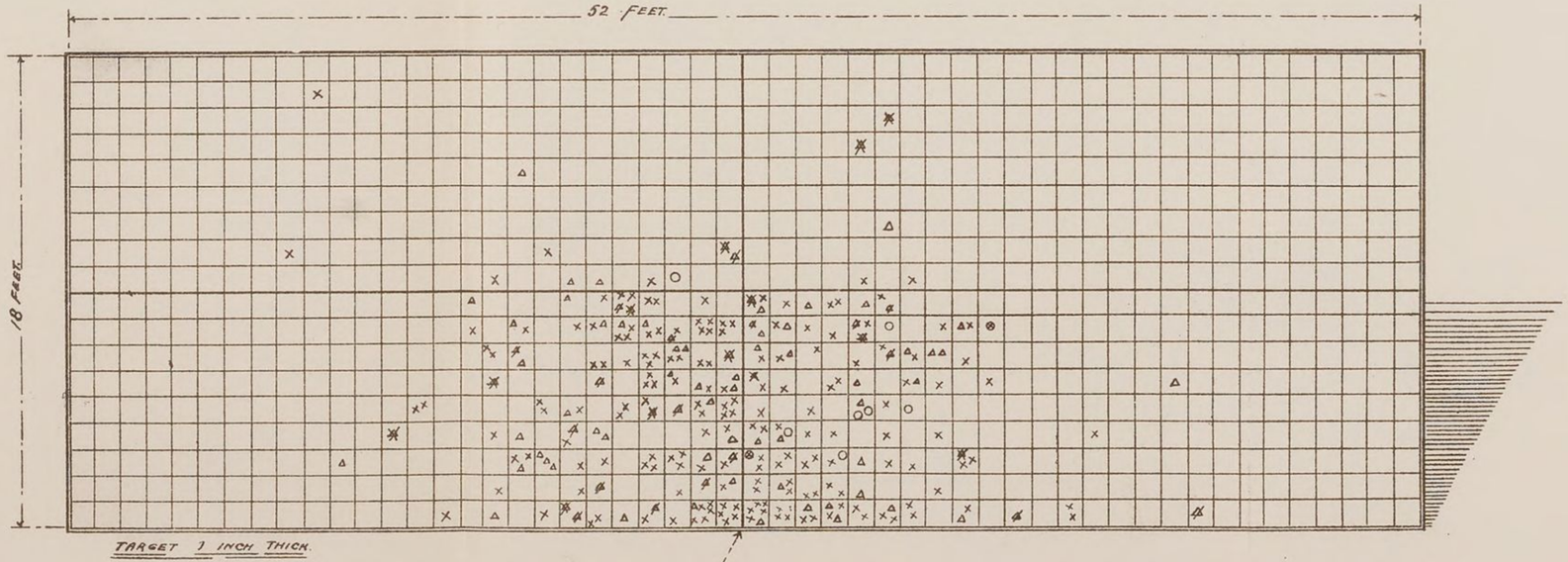


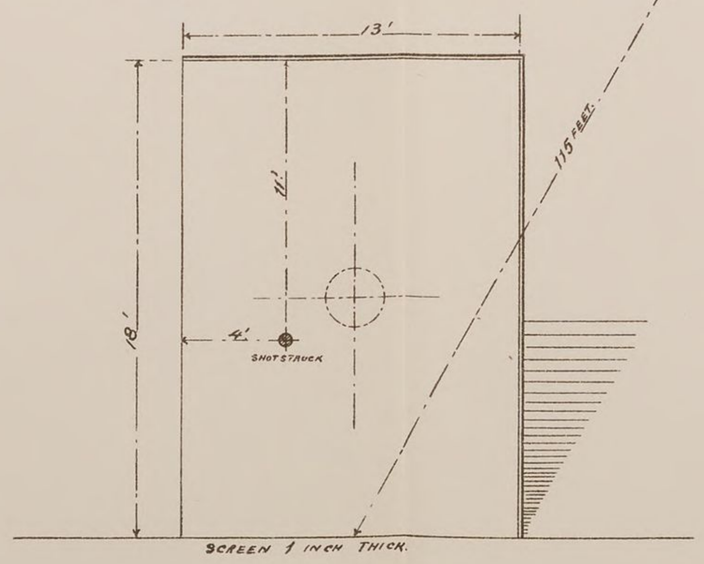




X	BULLETS THROUGH	169
⊗	" IMBEDDED	6
○	" MADE MARK	2
△	FRAGMENTS THROUGH	47
⧋	" IMBEDDED	19
⧋	" MADE MARK	13
	TOTAL	256.

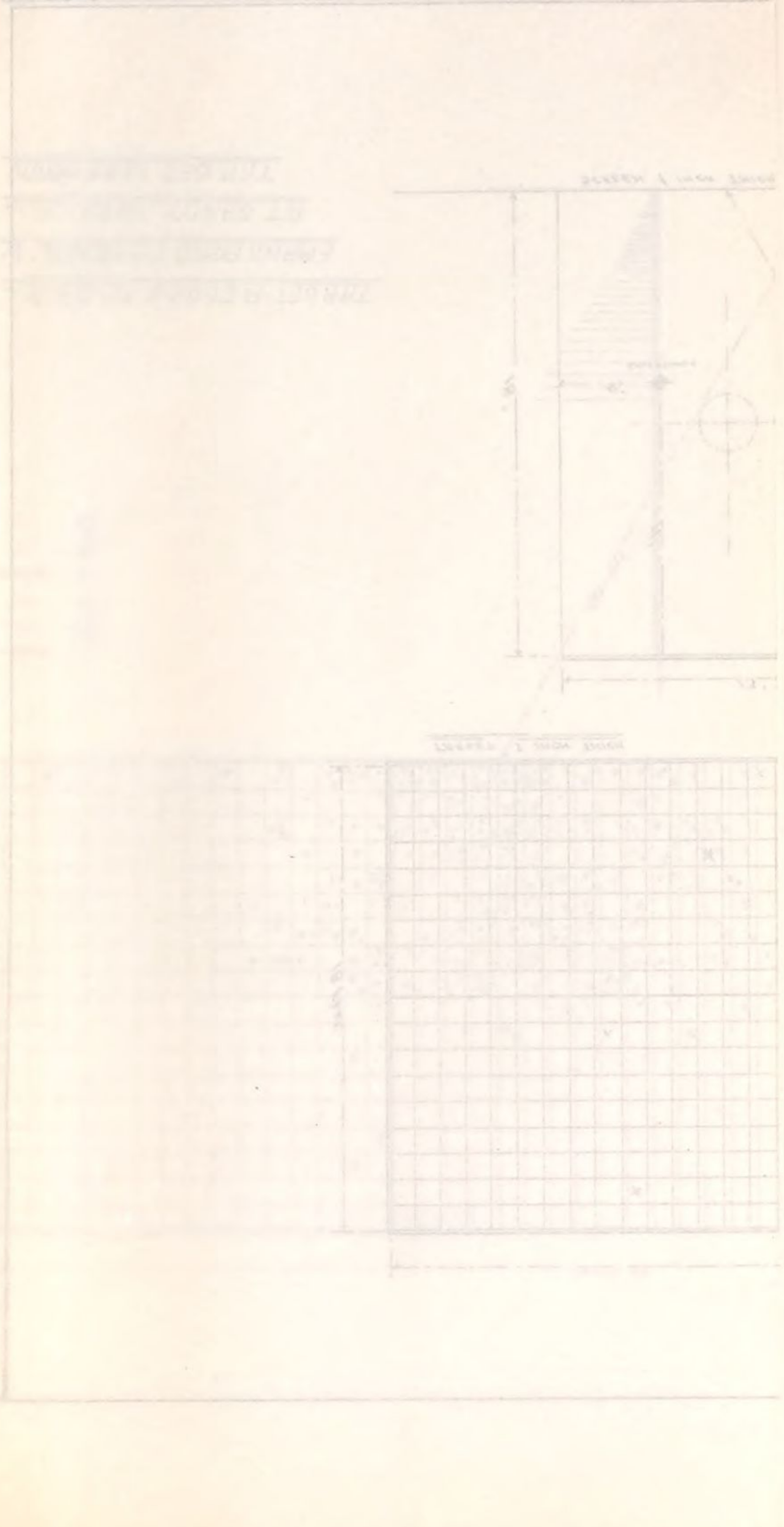
TARGET RECORD OF 3.6 B.L. RIFLE, (STEEL) No 1, WATERVLIET ARSENAL.
FRANKFORT ARSENAL SHRAPNEL. ROUND. No 2292.
AT SANDY HOOK. N.J. MAY 31st 1893.
TARGET 1000 YARDS FROM GUN.

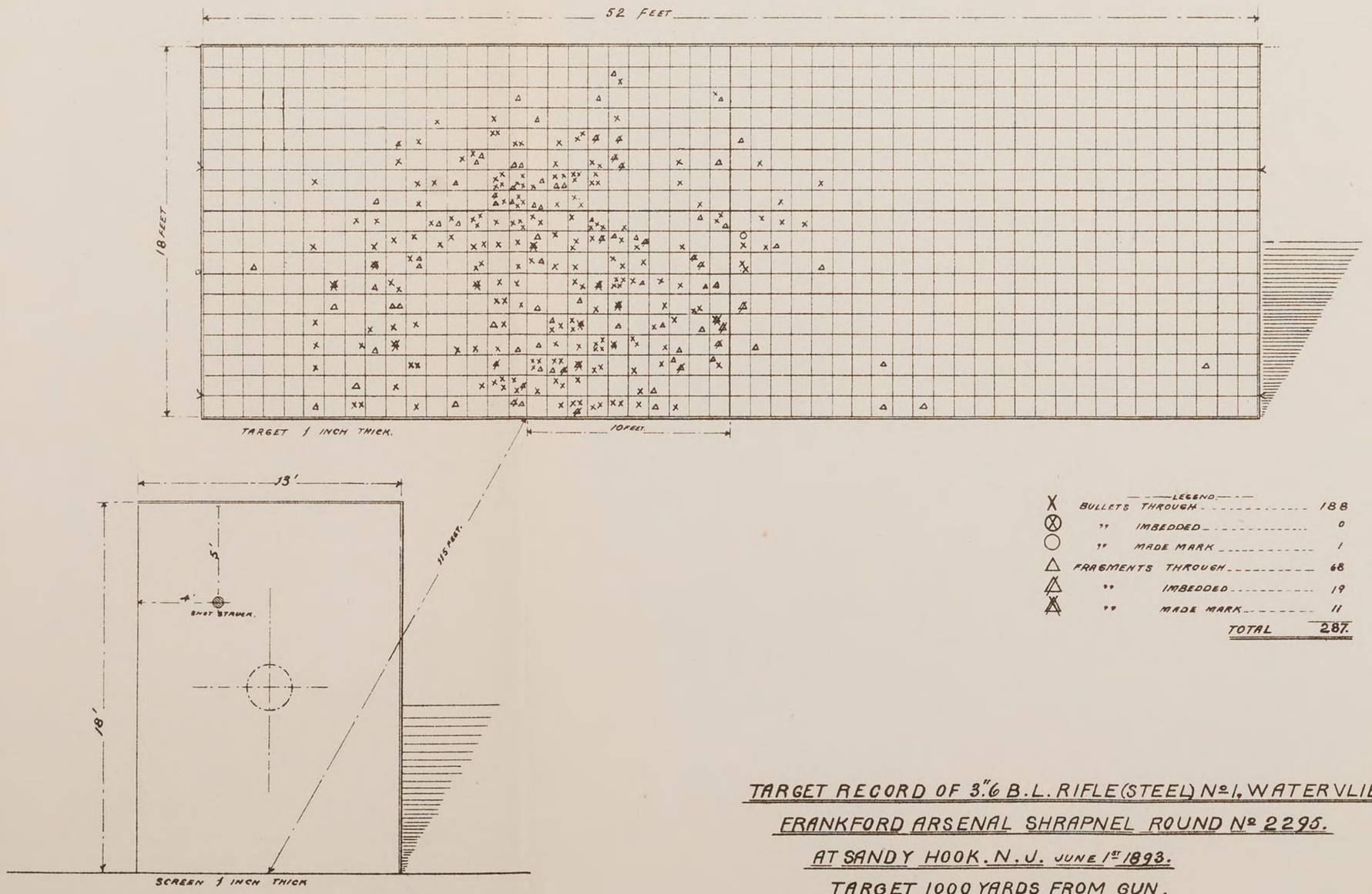




X	BULLETS THROUGH	176
⊗	" IMBEDDED	2
○	" MADE MARK	7
△	FRAGMENTS THROUGH	57
⧋	" IMBEDDED	18
⧋	" MADE MARK	13
	TOTAL	273.

TARGET RECORD OF 3.6 B.L. RIFLE (STEEL) No 1. WATERVLIET ARSENAL.
FRANKFORD ARSENAL SHRAPNEL ROUND No 2293.
AT SANDY HOOK. N. J. MAY 3/92 1893.
TARGET 1000 YARDS FROM GUN.





LEGEND

X	BULLETS THROUGH	188
⊗	" IMBEDDED	0
○	" MADE MARK	1
△	FRAGMENTS THROUGH	68
△	" IMBEDDED	19
△	" MADE MARK	11
	TOTAL	287.

TARGET RECORD OF 3.″6 B.L. RIFLE (STEEL) Nº 1, WATERVLIET ARSENAL.
FRANKFORD ARSENAL SHRAPNEL ROUND Nº 2295.
AT SANDY HOOK. N.J. JUNE 1ST 1893.
TARGET 1000 YARDS FROM GUN.

APPENDIX 40.

REPORT OF MANUFACTURE OF AMERICAN PROJECTILE COMPANY 3.2-INCH SHRAPNEL. BY LIEUT. W. W. GIBSON, ORDNANCE DEPARTMENT, U. S. ARMY.

(8 plates.)

WATERTOWN ARSENAL, *August 7, 1893.*

SIR: In compliance with your instructions I have the honor to submit the following report of the manufacture of electrically-welded shrapnel by the American Projectile Company, Lynn, Mass.:

FIRST DESIGN OF SHRAPNEL.

(See Plate I.)

The first electrically-welded shrapnel were made by drop forging a base A, then welding it to a piece of seamless tube B and afterwards pressing in a diaphragm 0.25 inch thick, into which had been crimped a brass tube, as C. Next a cast-steel head D was welded to the tube, completing the case. The brass tube was crimped into the head at the bottom of the fuse-thread hole. The shrapnel was then turned and banded. The bullets were introduced through two filling holes in the head; plaster of Paris was used as a matrix, and the holes afterwards plugged. This shrapnel was a failure. It was not strong enough to withstand the setback of the bullets when fired.

SECOND DESIGN.

In the next design an attempt was made to strengthen the weak parts in the first pattern. The diaphragm was made 0.375 inch thick, and a steel forging instead of a casting used for the head.

Resin was substituted for plaster of Paris as the matrix, being introduced through a single hole in side of head. This shrapnel was a marked improvement over preceding design. It did not break up so completely, due to the structural weakness, and the welds were much better. It was still not strong enough.

THIRD DESIGN.

This design was exactly like the preceding, except the diaphragm was 0.5 inch thick. It was successful on the whole, and about 300 of this pattern were accepted after passing the firing test. It was, however, liable to failure now and then, and this pattern was abandoned.

FOURTH DESIGN.

(See Plate II.)

The design now employed, and which has been successful in a high degree, was then adopted. It consists of a solid forged-steel case E (Plate I), machined inside and the weakening grooves slotted in. The powder chamber is formed in the base by a wrought-steel diaphragm 0.25 inch thick. A cast-iron tripod or support for the diaphragm is first pressed into the bottom of the case and the diaphragm then forced down on it, resting on a slight shoulder on the interior wall of case. Fifty tons pressure being used in forcing diaphragm assures the test of the diaphragm and secures the fitting of the tripod and diaphragm to each other and to the base without clearance. A forged-steel head is then welded on and a cast-iron powder tube, screwed into head, connects the fuse opening with the base powder chamber. The central tube stiffens the shrapnel by making the diaphragm carry the weight of head and fuse, and largely contributes to the resistance to upsetting at firing. The shrapnel is turned, banded, and filled as before described. At first it was intended to lacquer the shrapnel on the exterior, but a bronzing process proposed by the American Projectile Company was adopted and applied to the shrapnel of the first contract.

The receipt is as follows: 2 ounces tincture of steel, 2 ounces spirits of wine, $\frac{1}{2}$ ounce muriate of mercury (corrosive sublimate), $\frac{1}{4}$ ounce sulphate of copper, and 1 pint of boiling water.

This is the same receipt as is employed in bronzing guns. After the application of the mixture the shrapnel is covered with a heavy coat of oxide or rust, and two or three applications of oil were applied to produce an even dark brown coat. This process proved to be a failure, as the oil disappeared after a time and the shrapnel reverted to the rusty condition. The process was abandoned and a lacquer used for coating exterior.

Of the 1,500 shrapnel furnished by the Thomson Electric Welding Company under their contract of January 27, 1891, 200 of the old pattern (brass powder tube, $\frac{1}{2}$-inch diaphragm) were shipped to Fort Monroe Arsenal, 148 to Frankford Arsenal, and 21 to Watervliet Arsenal.

Of the present pattern (forged-steel case, cast-iron powder tube, diaphragm with tripod support) 836 were shipped to Frankford Arsenal. The balance had been sent to Sandy Hook Proving Ground from time to time for experimental and proof firing.

The contract was completed April 8, 1893. Of the 1,500 shrapnel furnished by the American Projectile Company under their contract of April 14, 1892, all of latest pattern (forged-steel case, cast-iron powder tube, diaphragm and support), 75 were expended at Sandy Hook Proving Ground in proof firing and 1,425 shipped to Frankford Arsenal.

This contract was completed July 31, 1893. The latest approved specifications for electrically-welded shrapnel, together with tracing, are given herewith.

Very respectfully, your obedient servant,

W. W. GIBSON,
Lieutenant, Ord. Dept., U. S. Army, Inspector.

The COMMANDING OFFICER WATERTOWN ARSENAL.

(4024–'93.)

SPECIFICATIONS.

The following specifications, including table of weights, dimensions, and allowed variations, are made additional to those dated December 10, 1891, accompanying proposals for 3.2-inch shrapnel opened at this office January 28, 1892, and are substituted for the "additional specifications for American Projectile Company 3.2-inch shrapnel," dated Ordnance Office, War Department, March 9, 1892.

The entire case shall be made of wrought steel electrically welded together so as to form a complete hardened wrought-steel case without joint. The powder chamber to be formed in the base by a wrought-steel diaphragm supported by a cast-iron spider and connected through the center of the shell (axially) to the fuse opening by a cast-iron tube of shape and dimensions shown on drawing. When assembled, the diaphragm and spider must be fitted to each other and to the base, without clearance. The bullets to be 34 to the pound, and each shell to contain not less than 165 bullets, which will be held firmly in position by a matrix of resin.

A plug of hard wood, as shown on the accompanying drawing, will be furnished with each shrapnel in lieu of the type-metal plug heretofore specified. And a browning process may, if made satisfactory to the Department, be used in place of a thin, black lacquer for coating the exterior of shrapnel.

The shrapnel will be made in accordance with design and drawing of the American Projectile Company, dated October 17, 1892, approved by the Chief of Ordnance December 27, 1892. Allowed variations from prescribed weight and dimensions are given in the following table:

Weight and dimensions.	Prescribed.	Allowed variations.
Weight (without fuse or bursting charge) .... pounds	12.0	2 ounces above or below.
Weight (without fuse or bursting charge) .... ounces	5.0	
Total length (without fuse) ..... inches	7.55	0.10 above or below.
Length of head (without fuse) ..... do	1.95	0.05 above or below.
Diameter of cylindrical portion ..... do	3.180	0.005 above or 0.01 below.
Diameter of head at front ..... do	2.00	0.025 below.
Radius of head:		
Outside ..... do	3.5	
Inside ..... do	3.29	
Thickness of base ..... do	0.70	0.02 above or below.
Thickness of diaphragm ..... do	0.25	0.02 above or below.
Thickness of walls:		
Powder chamber ..... do	0.35	0.02 above or below.
Cylinder ..... do	0.20	0.02 above or below.
Head ..... do	0.20	0.02 above or below.
Length of powder chamber ..... do	1.10	0.02 above or below.
Length of ball chamber ..... do	4.95	0.10 above or below.
Depth of fuse seat to end of thread, minimum .... do	1.20	
Total depth of fuse seat ..... do	1.50	0.03 above or below.
Diameter of fuse seat within threads ..... do	1.00	gauged.
Number of threads per inch ..... number	8.0	gauged.
Interior diameter of tube (cast iron) ..... inches	0.50	
Exterior diameter of band ..... do	3.30	0.005 above or below.
Width of band ..... do	0.50	0.01 above or below.
Distance of band from base ..... do	0.625	0.01 above or below.
Diameter of ball ..... do	0.526	
Weight of ball (34 to the pound) ..... grains	206.0	
Number of balls	170.0	5 below.

NOTE.—The total weight of shrapnel to be 13.5 pounds, including fuse 1 pound and bursting charge 3 ounces, to be supplied by the Ordnance Department.

The firing tests of the test lots of 5 shrapnel shall not be considered satisfactory and the lot of 100 shrapnel which they represent shall be subject to rejection, in the discretion of the Department, if the shrapnel

fired from the gun show marks of rifling to such an extent as to indicate undue deformation of the shrapnel in the bore of gun.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

ORDNANCE OFFICE, WAR DEPARTMENT,
December 27, 1892.

(5226–'92.)

REPORT OF FIRING TESTS.

SANDY HOOK PROVING GROUND, *July 21, 1893.*

SIR: I have the honor to forward herewith record of tests made in compliance with your instructions of June 20, 1893, of electrically-welded (American Projectile Company) shrapnel, 3.2 inch, of latest pattern, by firing at 1,000-yards range, through a screen, to obtain targets for dispersion. Three shots were fired with the screen 90 feet from the target and six shots with screen 115 feet from the target. Three of the six shots at 115 feet were thrown out, as it was found that on account of the position of the screen—10 feet to left of center of target—the cone of dispersion had been thrown so far to the left as to render it probable that some fragments and balls had missed the target which otherwise would have been counted as hits. The last three shots at 115 feet were made with screen opposite center of target, and are reliable.

Tracings of the targets thus made are forwarded herewith, also Table I, containing a summary of the results obtained, and Table II, comparative results of the electrically welded (American Projectile Company) Hotchkiss and Frankford Arsenal 3.2-inch shrapnel, in which 11 feet of the targets (vertical height) are used, so selected as that they shall all bear the same relation to the points of burst, the latter being taken 1 foot above the portion of the target selected.

* * * * * * *

Very respectfully, your obedient servant,

FRANK HEATH,
Captain Ord. Dept., U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(4024–'93.)

TABLE I.—*Results with six electrically-welded shrapnel, 3.2 inch.*

[Fired to burst on passing through screen placed in front of 1,000-yards target. Nos. 1, 2, and 3 screen 90 feet in front of target. Nos. 4, 5, and 6 screen 115 feet in front of target. Screen 18 feet high, 13 feet wide, and 1 inch thick. Target 18 feet high, 52 feet wide, and 1 inch thick.]

No. of shrapnel.	Point struck from center—				Hits.						
					Balls.			Fragments.			Total.
	Above.	Below.	Right.	Left.	Through.	Embedded.	Indents.	Through.	Embedded.	Indents.	
	Feet.	*Feet.*	*Feet.*	*Feet.*							
1	3	.....	½	.....	106	2	4	22	4	7	145
2	½	.....	.....	4	129	2	.....	16	5	1	153
3	5	.....	.....	4	125	.....	1	10	2	14	152
4	5	.....	.....	3½	112	1	1	24	6	.....	144
5	2	.....	.....	5½	92	3	7	15	5	.....	122
6	2	.....	.....	2½	96	6	3	15	6	7	133
Total	.....	.....	.....	.....	660	14	16	102	28	29	849

TABLE II.—*Comparative results of electrically-welded Hotchkiss and Frankford Arsenal shrapnel, 3.2 inch.*

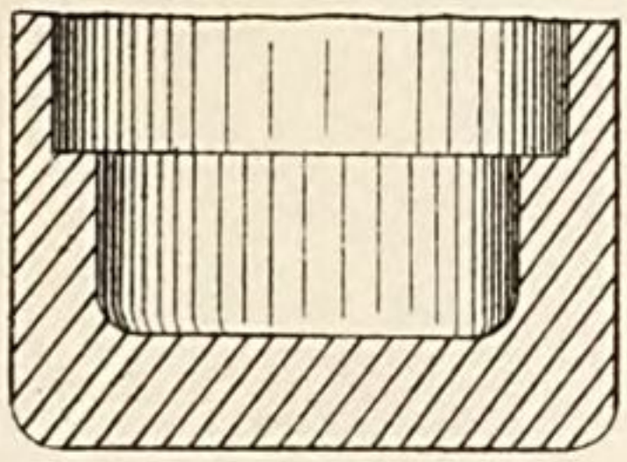
[Fired to burst on passing through screen placed in front of 1,000-yards target. Dimensions of vertical target, 11 by 52 feet, and 1 inch thick.]

Shrapnel.	Point struck on screen—		Hits.						
			Balls.			Fragments.			Total.
	Above portion of target used.	Left of center of target.	Through.	Embedded.	Indents.	Through.	Embedded.	Indents.	
	Feet.	*Feet.*							
Electrically welded [a]	1	4	93	.....	.....	9	1	11	114
Hotchkiss [a]	1	1½	73	12	.....	27	3	.....	115
Frankford [a] *	1	2⅝	95	1	1	44	35	25	201
Electrically-welded [b]	1	3½	76	1	1	19	6	.....	103
Hotchkiss [b]	1	5	51	1	4	23	4	.....	83
Frankford [b] *	1	⅙	85	1	1	22	18	15	142

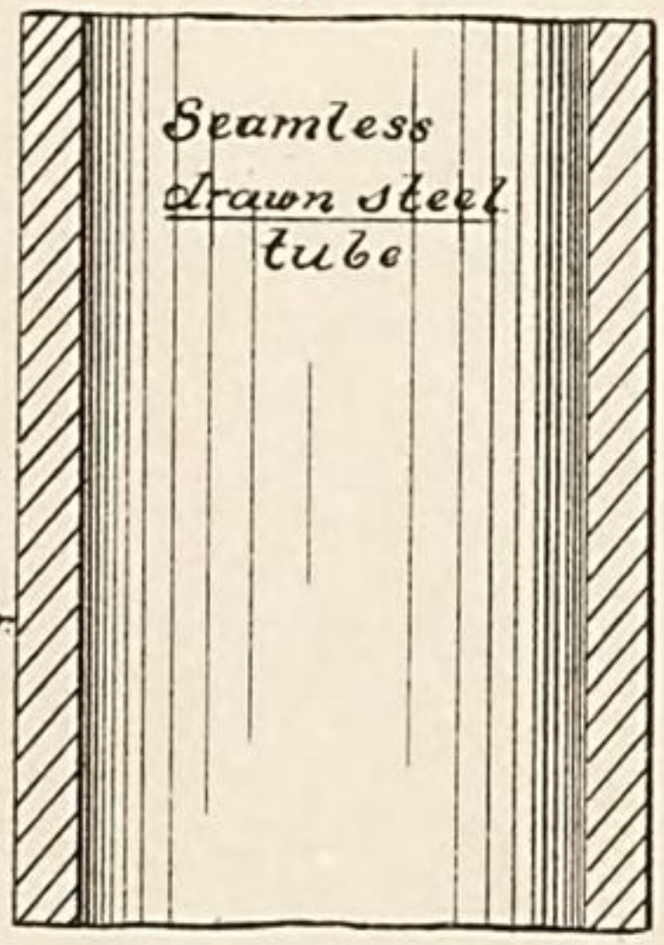
[a] Screen 90 feet in front of target.
[b] Screen 115 feet in front of target.
* Mean of three shots. Taken from firing records of August 11, 16, and 19, 1893, second indorsement (4024–'93).

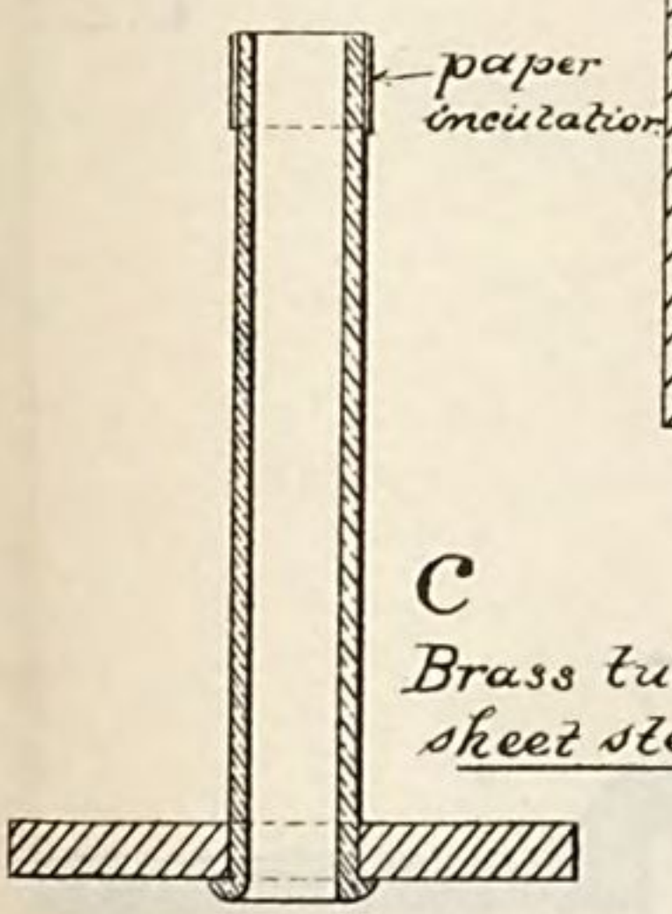
A

Drop forged steel base



B.



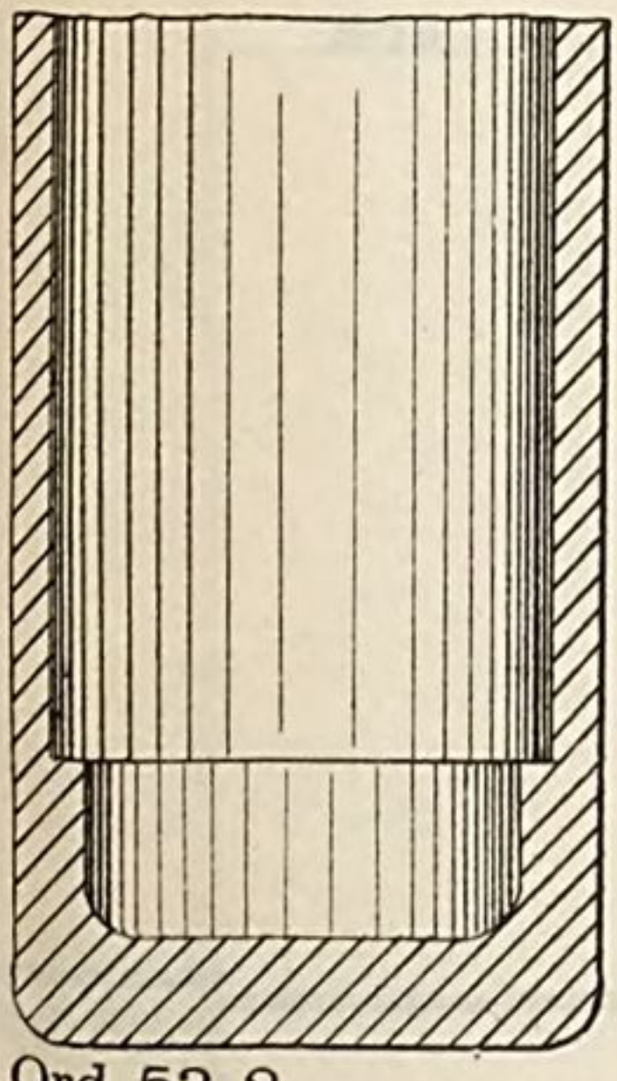


C

Brass tube and
sheet steel diaphragm

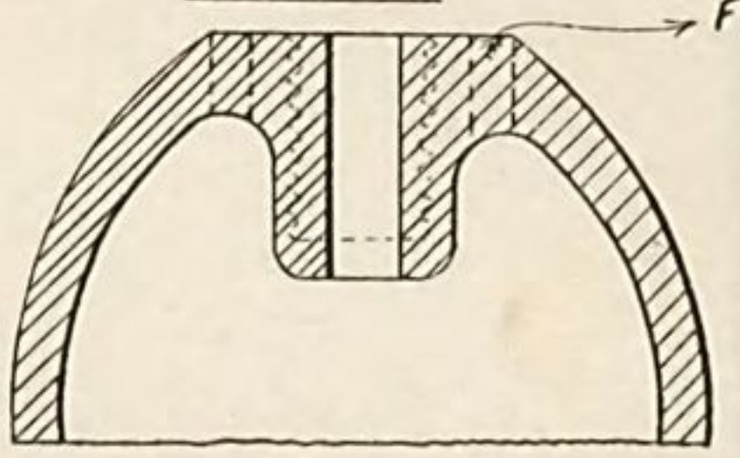
E.

Solid forged Steel Case

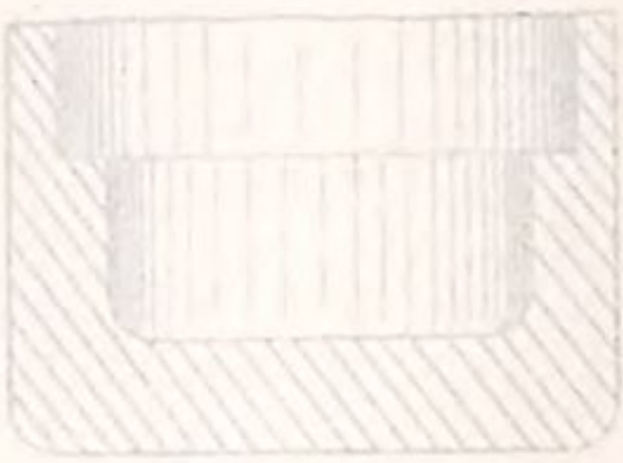


D.

Cast steel Head.

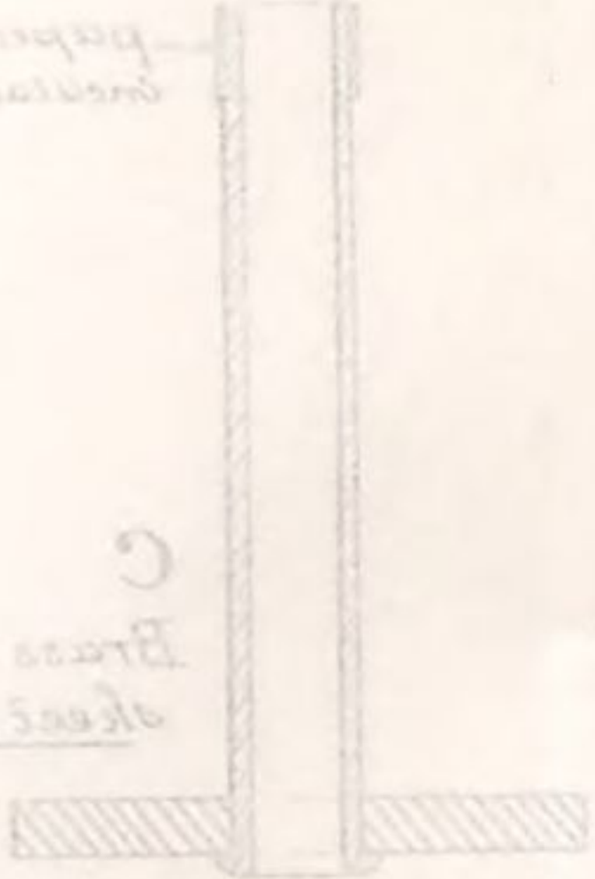


A.



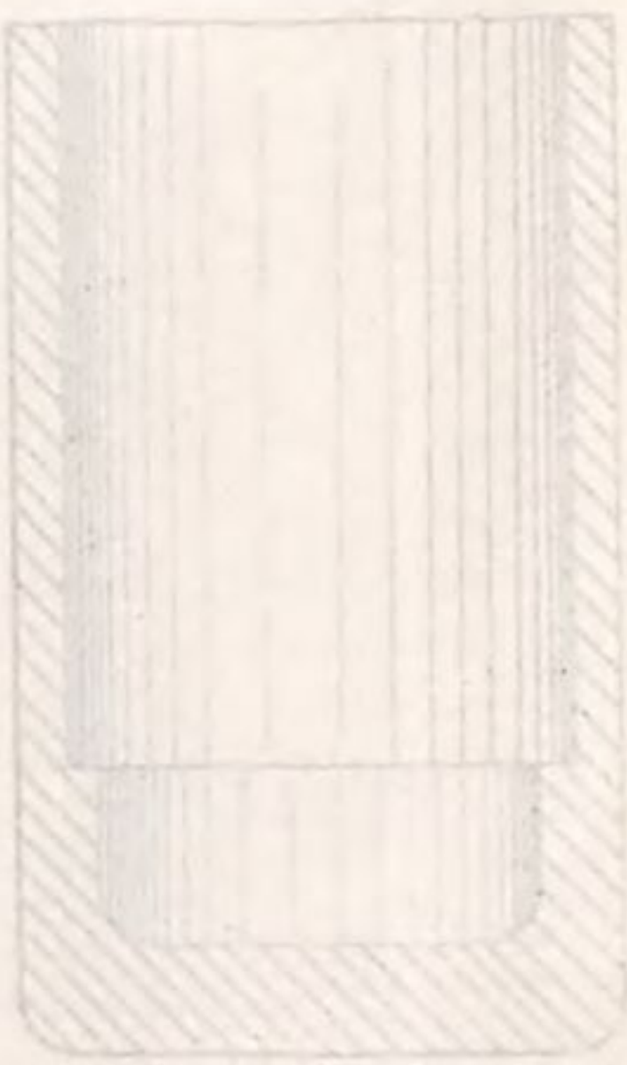
B.

C



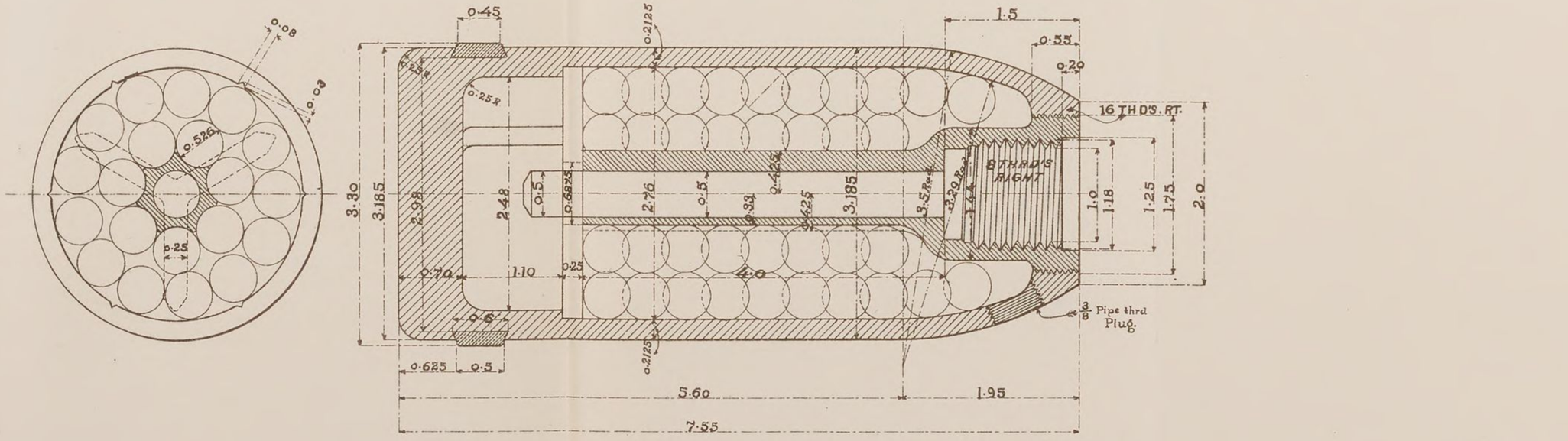
D.

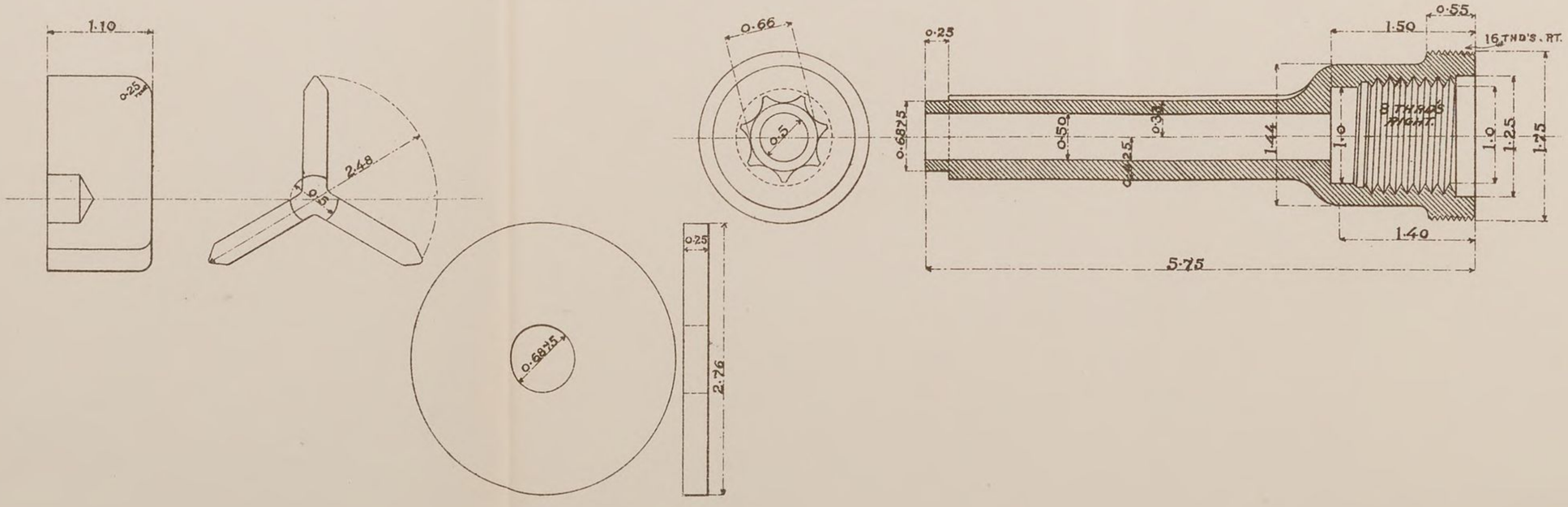
E.

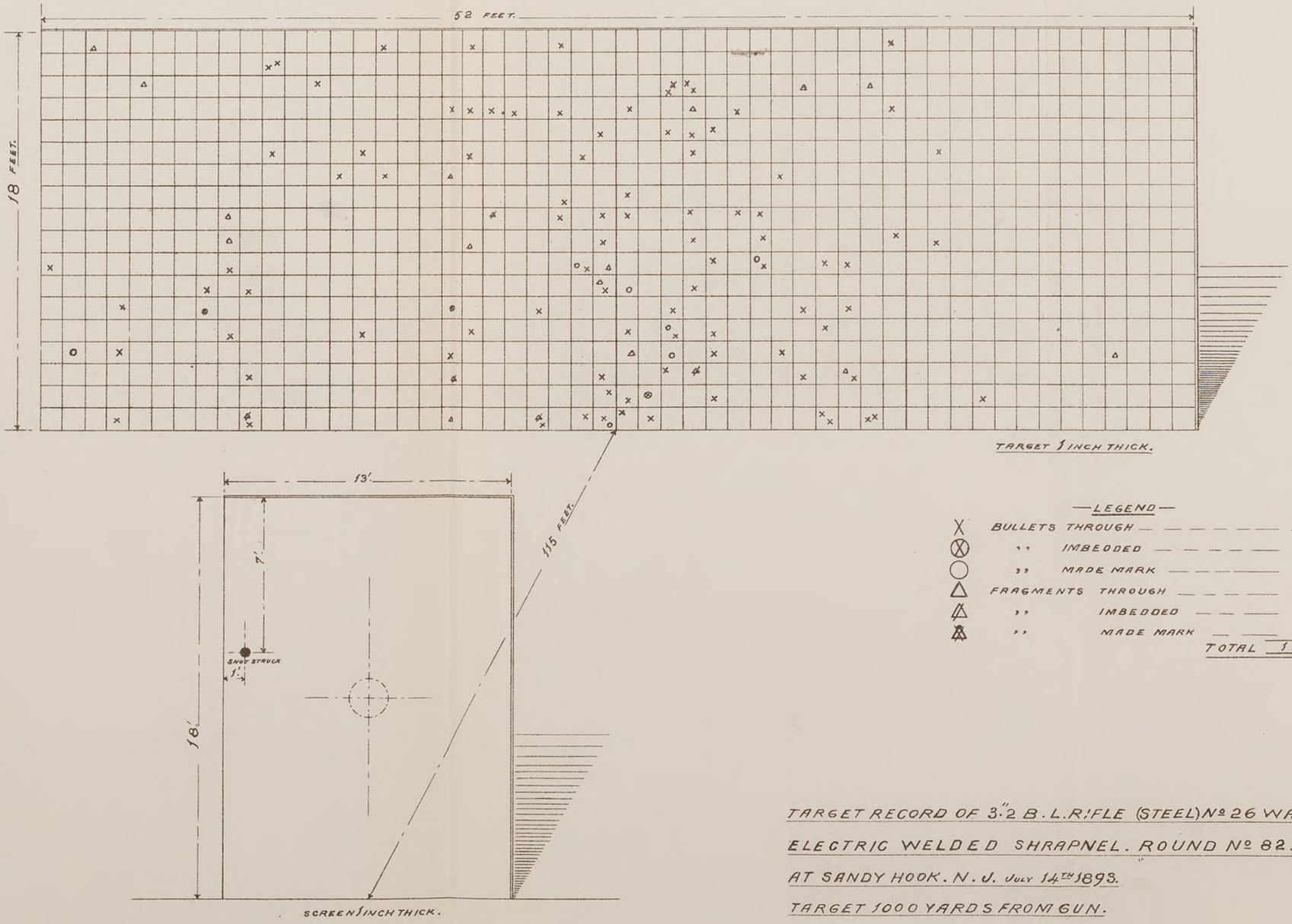


3.2 inch Electric welded Shrapnel.

American Projectile Co.







—LEGEND—

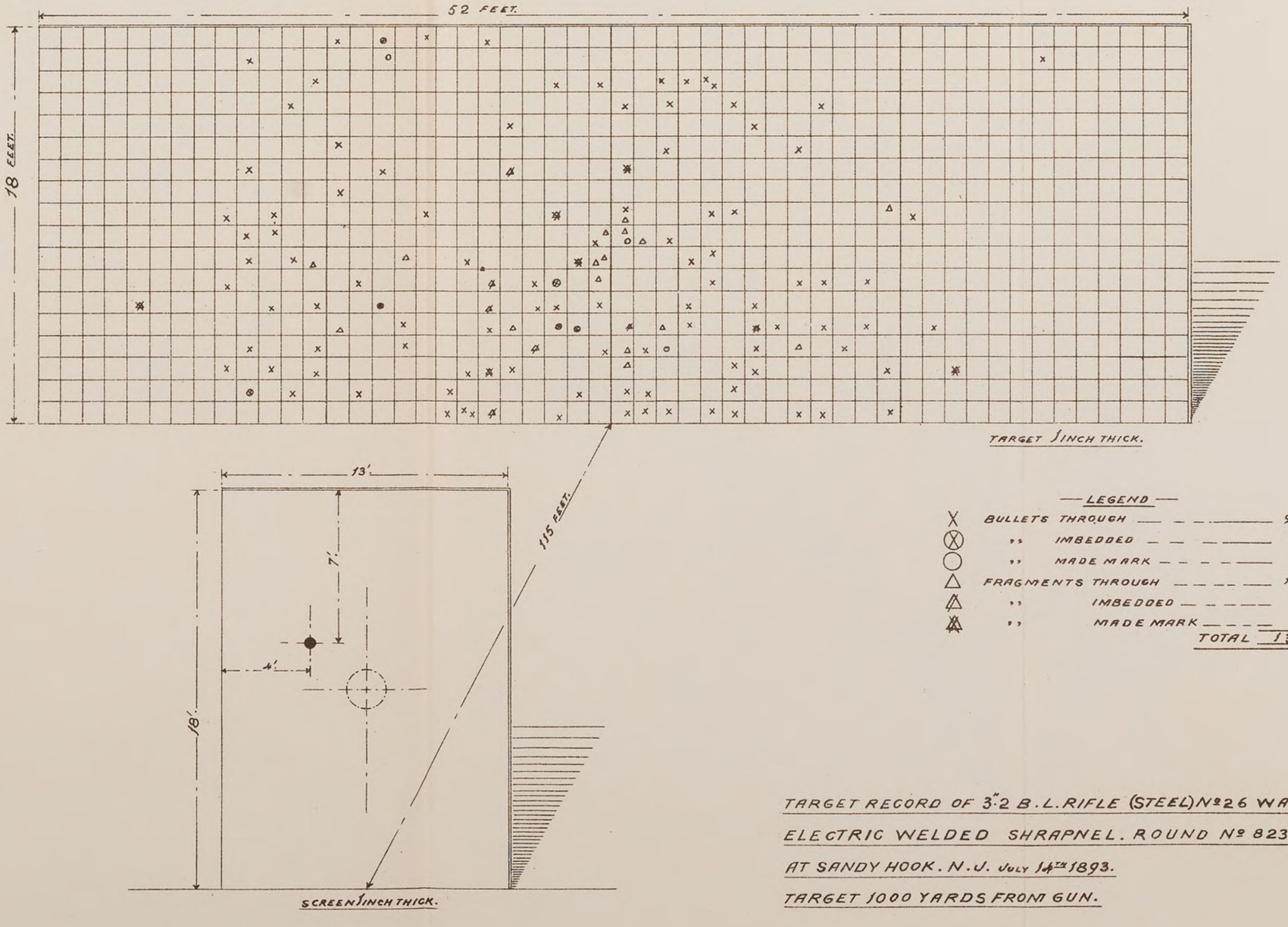
X	BULLETS THROUGH	92
⊗	" IMBEDDED	3
○	" MADE MARK	7
△	FRAGMENTS THROUGH	15
◬	" IMBEDDED	5
⟑	" MADE MARK	0
	TOTAL	122.

TARGET RECORD OF 3.2" B.L.RIFLE (STEEL) No 26 WATERVLIET ARSENAL.

ELECTRIC WELDED SHRAPNEL. ROUND No 821.

AT SANDY HOOK. N.J. JULY 14TH 1893.

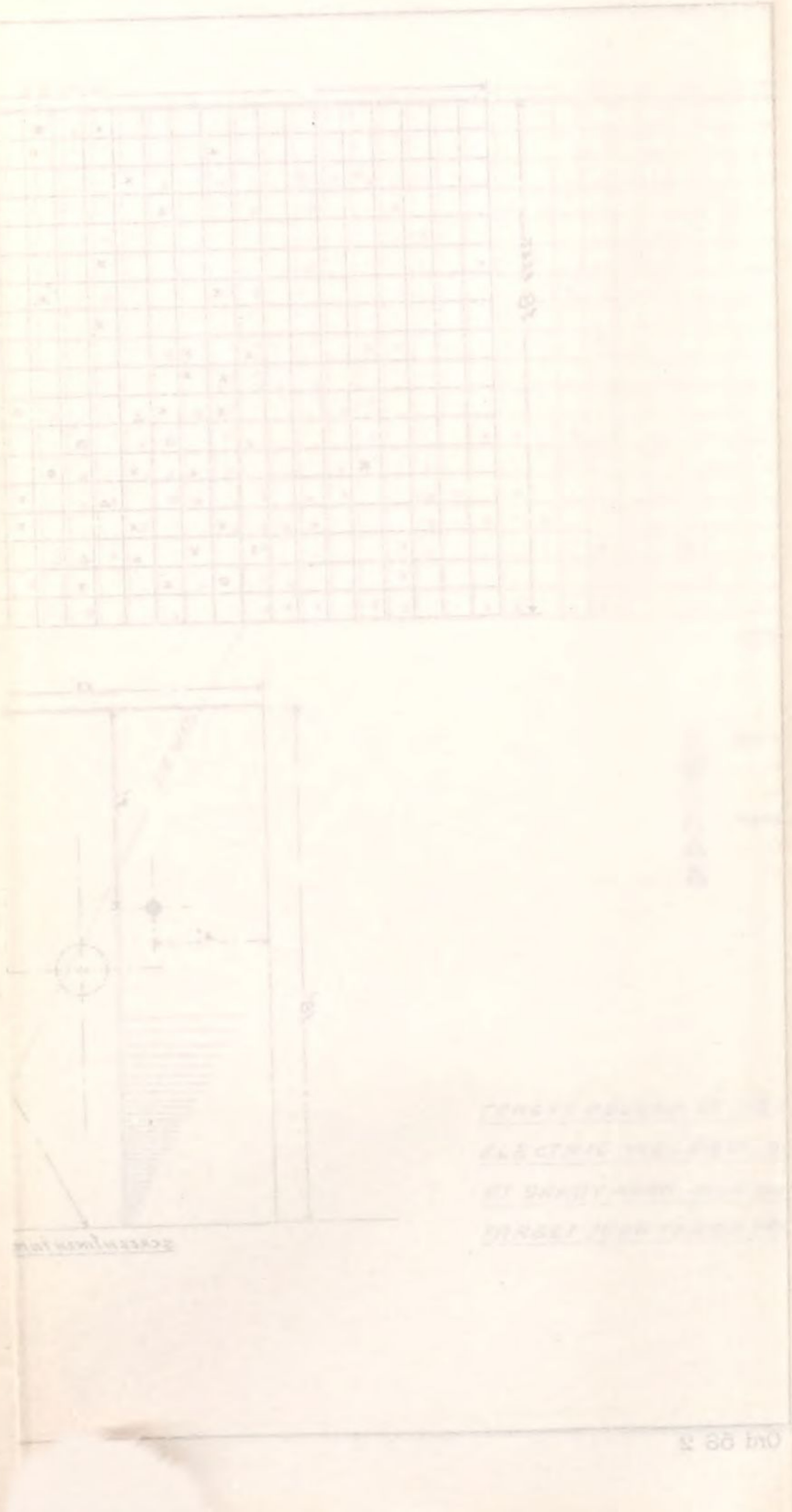
TARGET 1000 YARDS FROM GUN.

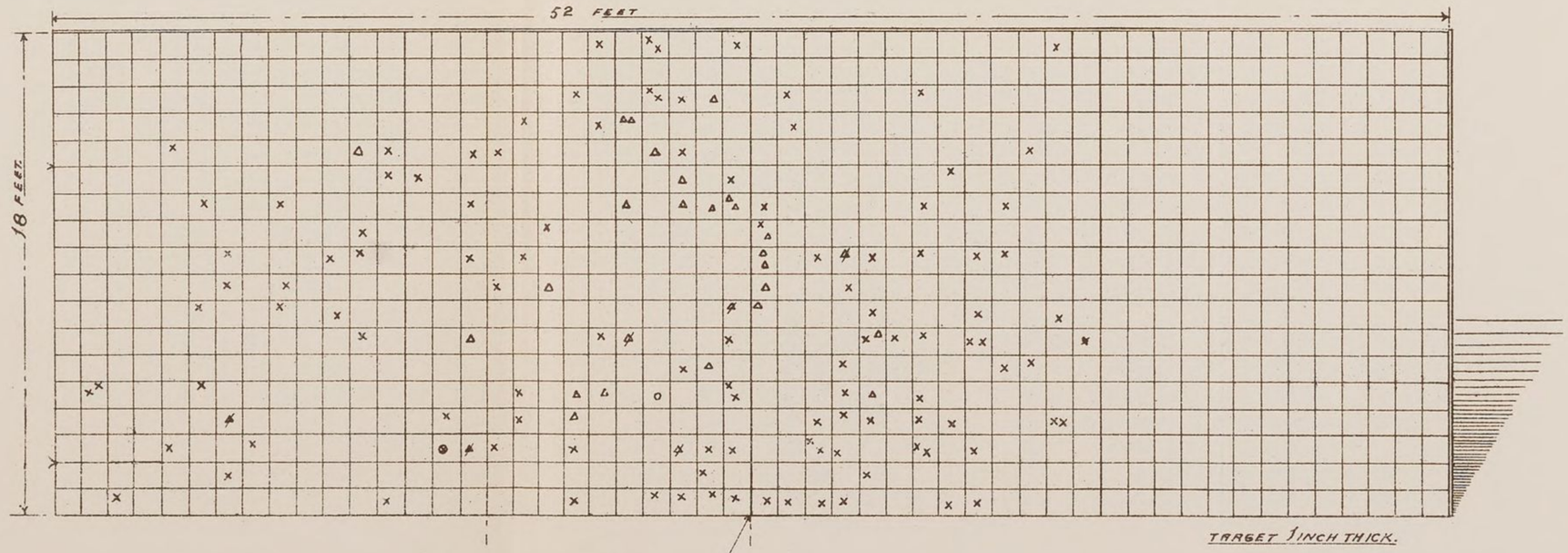


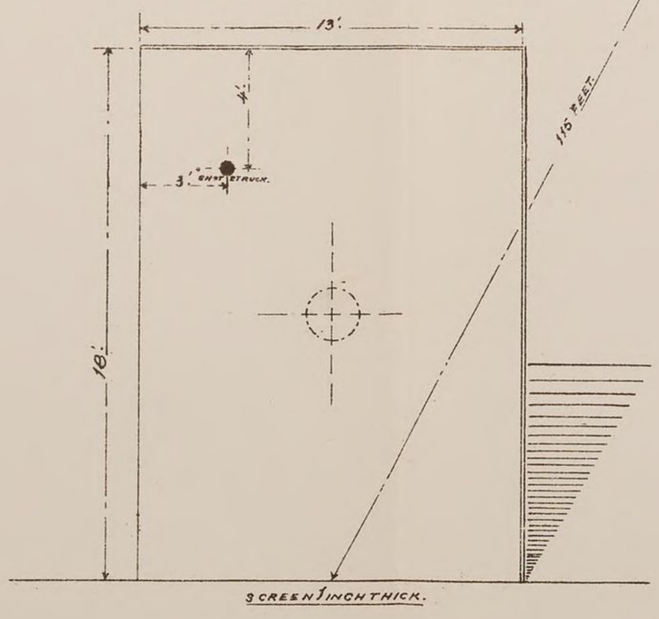
LEGEND

X	BULLETS THROUGH	96
⊗	" IMBEDDED	6
○	" MADE MARK	3
△	FRAGMENTS THROUGH	15
⧋	" IMBEDDED	6
⧋	" MADE MARK	7
	TOTAL	133.

TARGET RECORD OF 3".2 B.L. RIFLE (STEEL) Nº 26 WATERVLIET ARSENAL.
ELECTRIC WELDED SHRAPNEL. ROUND Nº 823.
AT SANDY HOOK. N.J. JULY 14TH 1893.
TARGET 1000 YARDS FROM GUN.



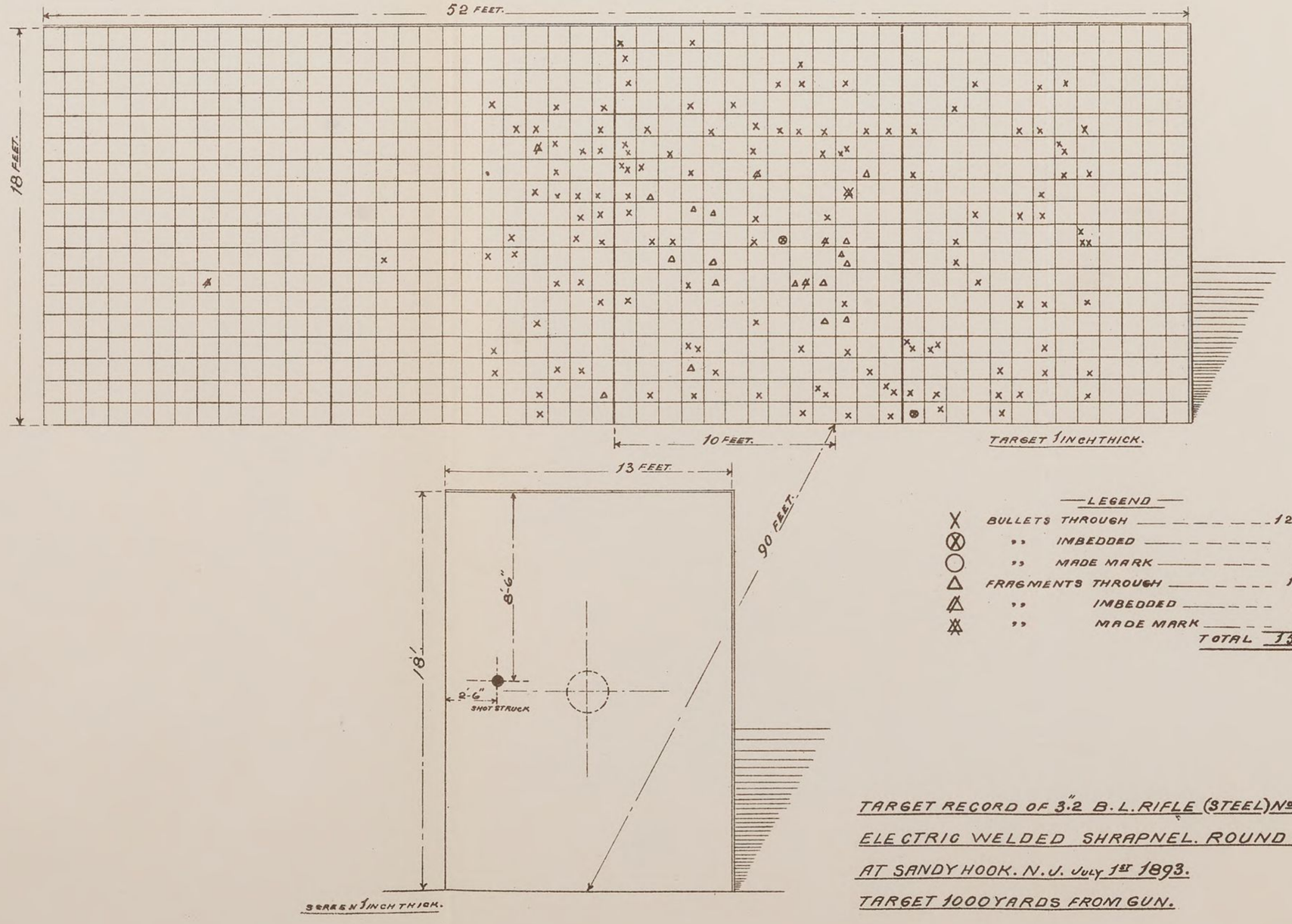




LEGEND

X	BULLETS THROUGH	112
⊗	" IMBEDDED	1
○	" MADE MARK	1
△	FRAGMENTS THROUGH	24
◬	" IMBEDDED	6
⧖	" MADE MARK	0
	TOTAL	144.

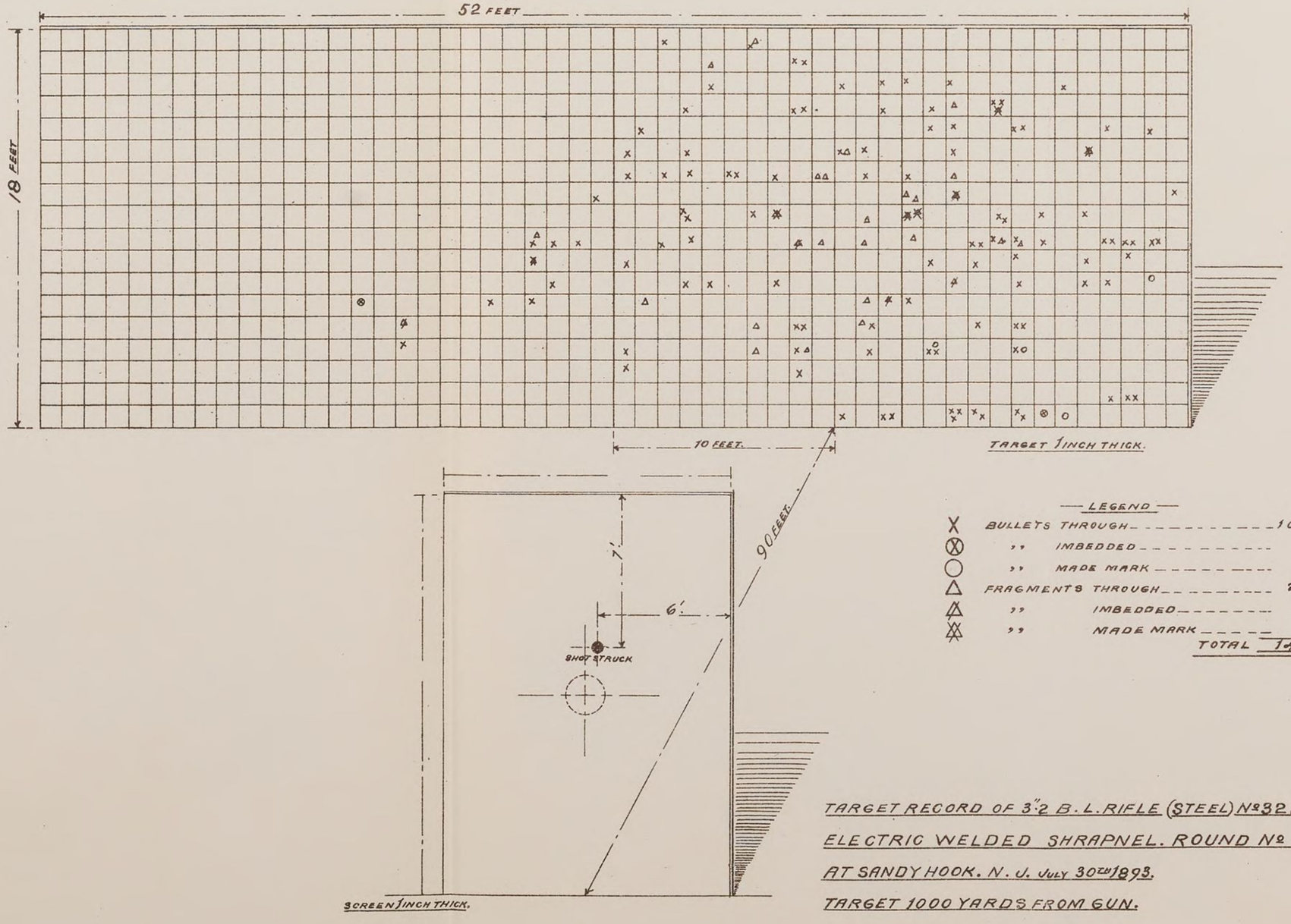
TARGET RECORD OF 3"2 B. L. RIFLE (STEEL) Nº 26 WATERVLIET ARSENAL.
ELECTRIC WELDED SHRAPNEL. ROUND Nº 820.
AT SANDY HOOK. N. J. JULY 14TH 1893.
TARGET 1000 YARDS FROM GUN.



—LEGEND—

X	BULLETS THROUGH	129
⊗	" IMBEDDED	2
○	" MADE MARK	0
△	FRAGMENTS THROUGH	16
◭	" IMBEDDED	5
✳	" MADE MARK	1
	TOTAL	153.

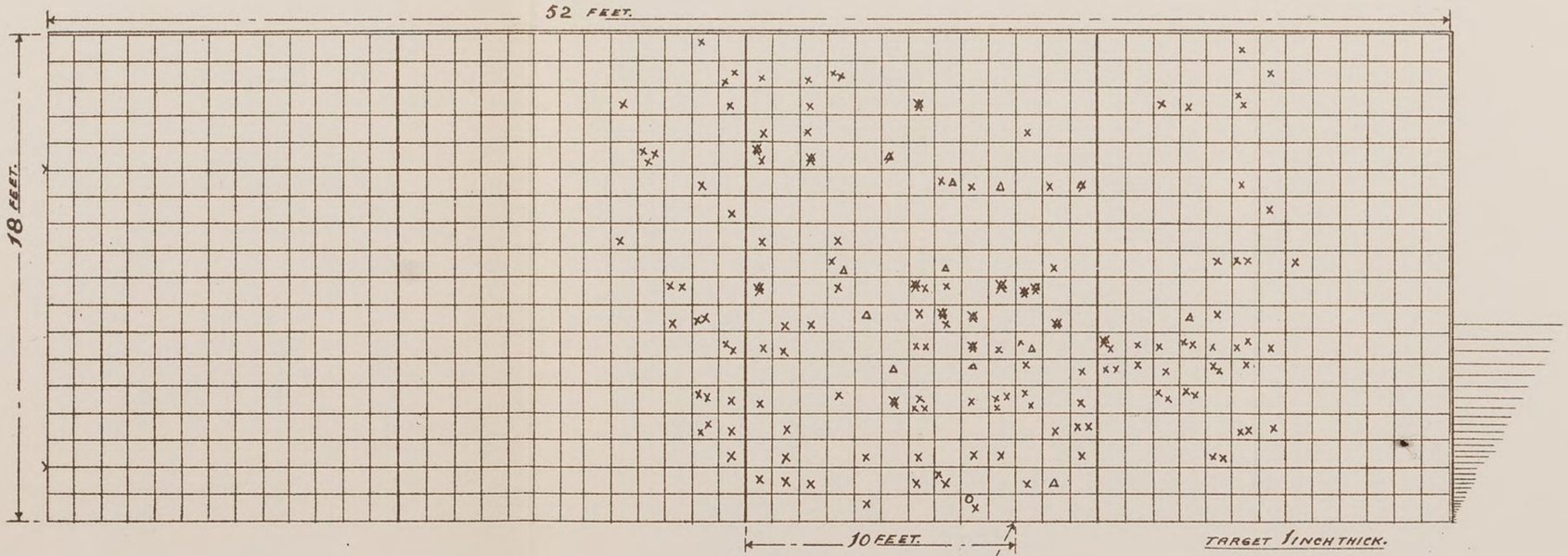
TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) No 32 WATERVLIET ARSENAL.
ELECTRIC WELDED SHRAPNEL. ROUND No 683.
AT SANDY HOOK. N.J. JULY 1st 1893.
TARGET 1000 YARDS FROM GUN.



LEGEND

X	BULLETS THROUGH	106
⊗	" IMBEDDED	2
○	" MADE MARK	4
△	FRAGMENTS THROUGH	22
⧋	" IMBEDDED	4
⧖	" MADE MARK	7
	TOTAL	145.

TARGET RECORD OF 3.2 B. L. RIFLE (STEEL) No 32, WATERVLIET ARSENAL.
ELECTRIC WELDED SHRAPNEL. ROUND No 681.
AT SANDY HOOK. N. J. JULY 30TH 1893.
TARGET 1000 YARDS FROM GUN.



LEGEND

X	BULLETS THROUGH.	125
⊗	" IMBEDDED	0
○	" MADE MARK	1
△	FRAGMENTS THROUGH.	10
◬	" IMBEDDED	2
⟑	" MADE MARK	14
	TOTAL	152.

TARGET RECORD OF 3"2 B. L. RIFLE (STEEL) Nº32 WATERVLIET ARSENAL.
ELECTRIC WELDED SHRAPNEL. ROUND Nº 684.
AT SANDY HOOK. N. J. JULY 1ST 1893.
TARGET 1000 YARDS FROM GUN.

APPENDIX 41.

FUSE PUNCH FOR FRANKFORD ARSENAL POINT COMBINATION FUSE.

(1 plate.)

SPRINGFIELD ARMORY, MASS.,
February 10, 1893.

SIR: In conformity with your instructions I have the honor to submit herewith a description of the fuse punch for cutting the time train of the Frankford Arsenal point combination fuse, 15 seconds, model 1891, or 28 seconds, model 1892.

DESCRIPTION.

The punch consists of the following parts, viz: 2 arms (1 upper, 1 lower), 1 punch pin, 1 binding screw, 1 spring, 2 screws for spring, 1 hinge bolt and 1 dowel pin, 1 hinge-bolt nut.

The parts are made of low steel, with the exception of the spring and pin, which are of cast steel. The punch pin is pointed at one end and headed at the other. It is set in a hole drilled in one of the arms and is inserted from the outside of the arm, the head bringing up against a shoulder in the hole and preventing the pin from passing entirely through. The binding screw engages in a thread, tapped in the larger part of the hole, and supports the head of the punch pin when the point strikes the fuse. The spring, which is screwed to the arm by the two screws, engages projections on the under side of the head of the binding screw, and holds it in the position in which it is placed.

On the inner side of the other arm, and opposite the punch pin, there is a curved recess to hold the fuse.

The two arms are pivoted upon the hinge bolt, which is held in place by its nut. The dowel pin prevents the hinge bolt from turning when the nut is screwed up.

On the interior curved portion of each arm, commencing 0.5 inch from the end and extending for a length of 1.375 inches, are cut serrations for use in removing tin-foil cover of fuse.

Weight of the punch, 12½ ounces; length of the punch, 8⅞ inches.

Respectfully,

D. M. TAYLOR,
Captain, Ordnance Department.

The COMMANDING OFFICER.

Materials required for the fabrication of 1,000 fuse punches, for cutting the time train of the Frankford Arsenal point combination fuse, 15 seconds, model 1891, or 28 seconds, model 1892.

Material.	Amount.	Part.
	Pounds.	
Low steel, 0.9 by 0.7 inch	1,000	Arms.
Cast-steel wire, No. 6, Stubbs gauge	6.75	Punch pins.
Cast-steel wire, No. 11, Stubbs gauge	4	Springs and screws for same.
Cast steel, 0.5 inch round	15	Binding screws.
Norway iron, 0.5 inch round	15	Hinge bolts and nuts.
Iron wire, No. 9, Stubbs gauge	3	Dowel pins.

A. MORDECAI,
Colonel, Ord. Dept., U. S. Army, Commanding.

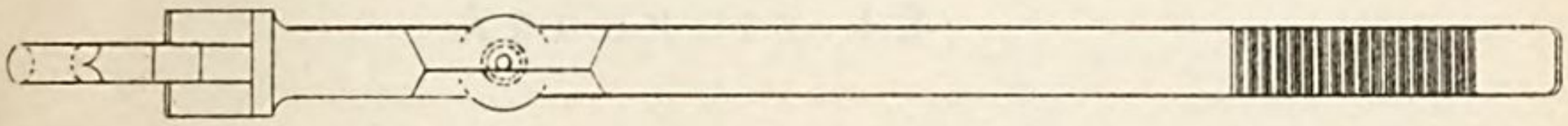
SPRINGFIELD ARMORY, MASS., *March 30, 1893.*

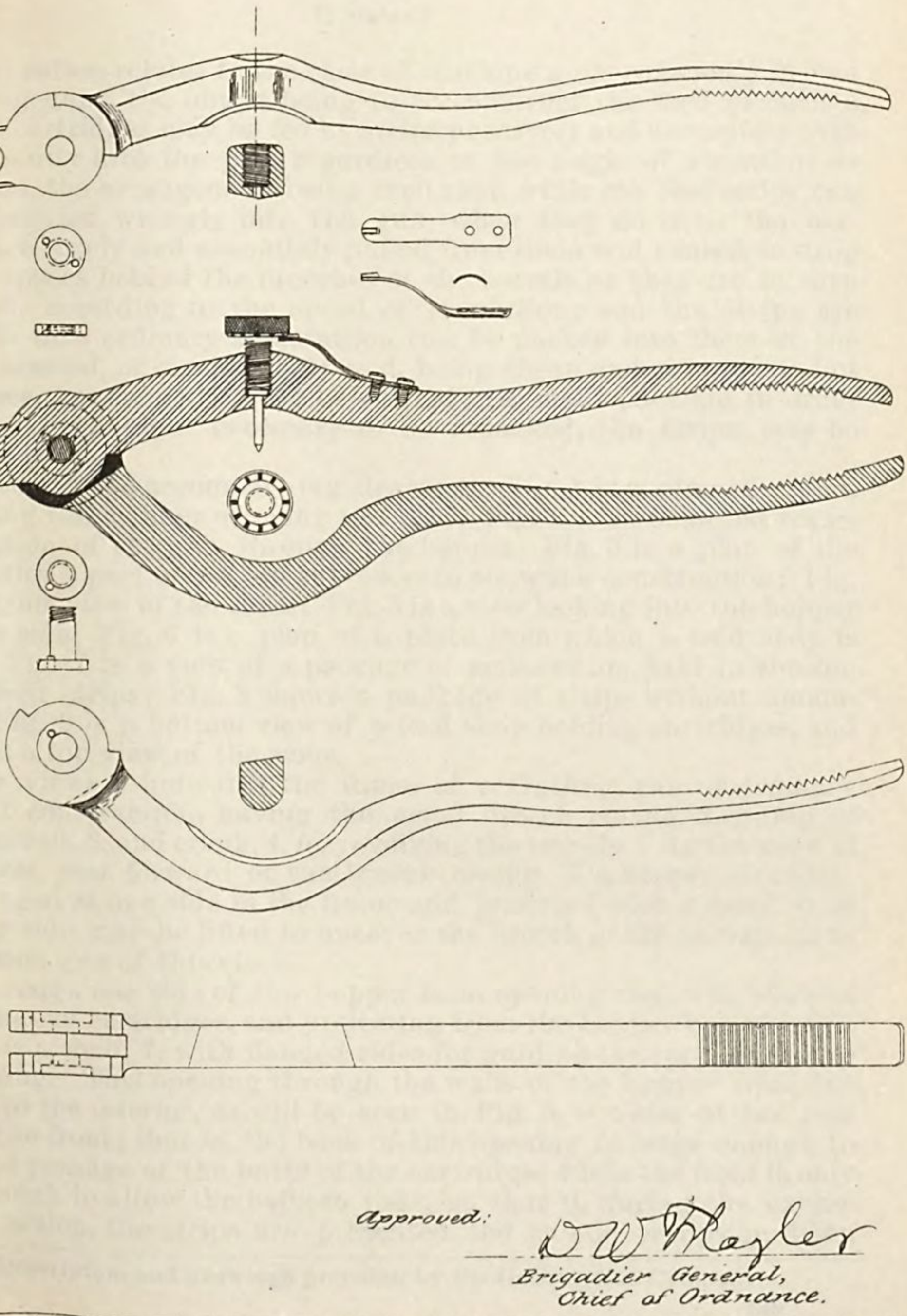
(1853–'93.)

FUZE PUNCH,

FOR FRANKFORD ARSENAL

POINT COMBINATION FUZE.





Approved:

D W Kegler

Brigadier General,
Chief of Ordnance.

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APPENDIX 42.

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*THE NEW POSITIVE FEED FOR THE GATLING MACHINE GUN.**

(3 plates.)

The invention relates to the class of machine guns commonly known as Gatling guns, the object being to so construct the feed of such a gun that cartridges may be fed by strips positively and accurately with great rapidity into the gun, regardless of the angle of elevation or depression, the arrangement being such that, while the feed strips can not be inserted wrongly into the gun, when they do enter the cartridges are surely and absolutely pulled from them and caused to drop into the spaces behind the breeches of the barrels as they are in turn presented, according to the speed of revolution; and the strips are simple, so that ordinary ammunition can be packed into them at the factory, arsenal, or on the field; and, being cheap and occupying but little space, a large supply can be carried in a small package, in order that after use, unless necessary to be repacked, the strips may be abandoned.

Referring to the accompanying drawings, Fig. 1 is a plan of a gun, illustrating the manner of using the feed; Fig. 2 is an enlarged transverse section of the gun, through the hopper; Fig. 3 is a plan of the hopper, with a part of the top cut away to show the construction; Fig. 4 is a bottom view of the same; Fig. 5 is a view looking into the hopper from the side; Fig. 6 is a plan of a plate from which a feed strip is formed; Fig. 7 is a view of a package of ammunition held in the improved feed strips; Fig. 8 shows a package of strips without ammunition; Fig. 9 is a bottom view of a feed strip holding cartridges, and Fig. 10 is a top view of the same.

In the views 1 indicates the frame of a Gatling gun of ordinary form and construction, having the usual breech casing, 2, group of rotary barrels, 3, and crank, 4, for revolving the barrels. At the rear of the barrels, just forward of the breech casing, is a hopper, 5, which, being hinged at one side to the frame and provided with a catch, 6, at the other side, may be lifted to uncover the breech of the barrels, as in the common gun of this class.

Cut through one side of this hopper is an opening that will allow of the passage of cartridges, and projecting from the hopper beneath this opening is a shelf, 7, with flanged sides for guiding the cartridges into the opening. This opening through the walls of the hopper from the exterior to the interior, as will be seen in Fig. 5, is wider at the rear than at the front; that is, the back of this opening is large enough to admit the passage of the butts of the cartridges while the front is only large enough to allow the balls to pass, so that if, during the excitement of action, the strips are presented end to end or upside down

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* Description and drawings prepared by the Gatling Gun Company.

they can not be thrust in to clog the mechanism and disable the gun. Placed over this guiding shelf and held to the sides by screws is a thin plate, 8, formed of spring metal, the inner end of which is concaved and extends into the interior of the hopper to a position nearly over the center of the carrier cylinder, 9, which is of the ordinary form used with these guns. The curved inner end of this plate bears with a yielding pressure upon the middle of the backs of the cartridge feed strips when they pass through the gun, and, while yielding for any inequalities, unevenness, or vibrations, it holds the strips so that the wedge will remove the cartridges from the prongs.

A narrow opening, 10, is made from the interior of the hopper through the side opposite the cartridge opening, and in the walls of the hopper, on the lower side of this opening, mortises, 11, are cut. Along the middle of the bottom wall of this opening, between the mortises, is a dovetail tenon, 12 (Figs. 2 and 3), and secured on this is a hard-metal wedge, 13. The upper surface of this wedge is almost flat, while the lower surface increases in thickness approximately on the arc of revolution of the perimeter of the carrier cylinder, 9, and the point of the wedge is adjusted to a position very near but slightly below the end of the spring plate that projects from the opposite side. Grooves, 14, are cut in the lower inner corners of the walls of the shelf, and at any time the surface of the shelf may be extended by inserting a plate in the grooves. The underside of the shelf, 7, has a dovetail tenon (Fig. 2), and on this is slipped and secured a guard, 16, which throws out the exploded cartridge shells that have been forced from the lock blocks and carrier by means of the usual plow, 17 (Figs. 4 and 5).

The frame, barrels, lock cylinders, lock blocks, and mechanism for revolving and reciprocating them are the same as in the common form of Gatling gun. The cartridge feed strips of indefinite length are cut or stamped to shape from thin, cheap sheet metal, preferably tin or brass, that has some resiliency but which is pliable under sufficient tension. Rows of ∪-shaped slits are cut each side of the center along the strips, and opposite each slit a small rectangular socket, recess, or slot, 19, is punched. Usually at the time these slits are cut the tongues are bent outward, forming the circular prongs, 20, which have a loop of a diameter slightly smaller than the cartridges they hold. When the cartridges are thrust into the clasp of the prongs a portion of the rims of their heads enter the rectangular slots opposite the prongs, so the cartridges can not slip or slide endwise. The front ends of the strips are bent or curved upward, so that when thrust into the large opening in the hopper they will not catch under the wedge, but pass out on the other side through the thin opening above the wedge.

These strips, which are very cheap and easily formed, may be transported or stored in packages without ammunition, as shown in Fig. 8, so a large supply can be kept in a small space until desired for use, or the prongs may be bent out at the factory or arsenal and the cartridges slipped into their clasp. When filled with cartridges the strips may be packed in bundles of any desired size, as illustrated in Fig. 7, where four such strips are shown, and then wrapped in a covering of thin paper or the like. As the strips are stiff a paper-board box is necessary, and the package will occupy but little more room than the ammunition alone. When it is desired to use such a package, the wrapper is torn off and the curved end of the strip thrust into the large opening of the hopper. The front edge of the opening in the hopper is curved, so as to be only large enough for the passage of the ball ends of the

cartridges, and not of a size that will admit the butts, to prevent any chance of the strips being inserted into the hopper wrong end foremost, which would clog the mechanism and disable the gun. The strips can only be inserted right end first, and, as the successive edges of the grooves in the carrier cylinder come around when the gun is in action, they catch the successive cartridges as presented and push them forward, until, by contact with the wedge, the cartridges are forced from the clasp of the prongs of the strip. The strip then passes out through the narrow slit, the prongs traveling through the mortises while the cartridges drop into the grooves of the carrier cylinder and are fed to the barrels by the common reciprocating lock mechanism of such a gun.

Usually, after firing, the cheap sheet-tin strips with the prongs bent out, as shown on the right of Fig. 2, are left on the ground where they drop, but of course they can be picked up and the prongs bent down, so they may be used again to receive and conduct cartridges into the gun. The prongs clasp the cartridges with a slight resiliency, and hold a portion of the edge of the rim in the small rectangular slots in such manner that they can not slip endwise from the strips, but are presented evenly to the gun, regardless of the angle of elevation or depression at the time of use. Of course, if desired, these strips may be of indefinite length, or may be attached one to another to form a continuous belt, but on account of the stiffness of the strip they can be readily handled and quickly fed to the gun in ordinarily short lengths to permit of very rapid firing.

The plate which covers the cartridge opening into the hopper and extends to the center is curved and somewhat elastic, so as to bear upon the top of the strips with a yielding pressure and hold them in position, and while given to inequalities and unevennesses it holds the strips so the wedge will surely pull the cartridges as they are presented from the grasp of the prongs. The wedge is easily adjusted so it may be made to come into the exact position to pull the cartridges from the strips, and is removable at any time, so it can be sharpened, cleaned, or replaced with a new wedge should it become damaged. The whole hopper is simple, cheap, and readily adjustable, so the metallic plates referred to holding the cartridges may be surely and positively fed through the gun during action with great rapidity without danger that any of the cartridges will miss fire, or that they will get into the gun in such a manner as to disable the mechanism.

PLATE I.

POSITIVE FEED FOR GATLING GUN.

CARTRIDGE HOLDING FEED-STRIPS AND METHOD OF FEEDING.

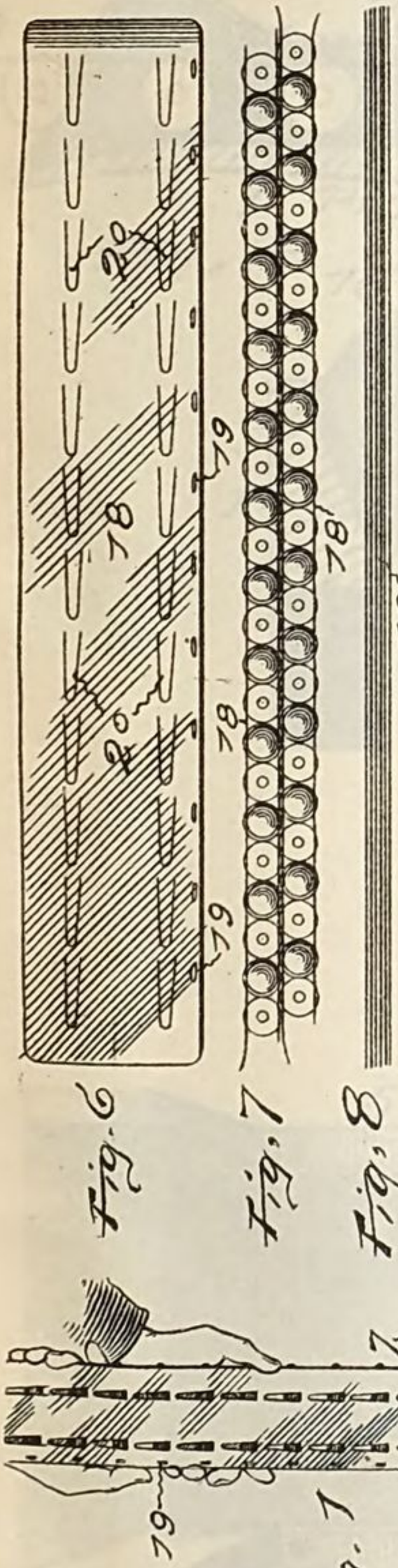


Fig. 6.

Fig. 7.

Fig. 8.

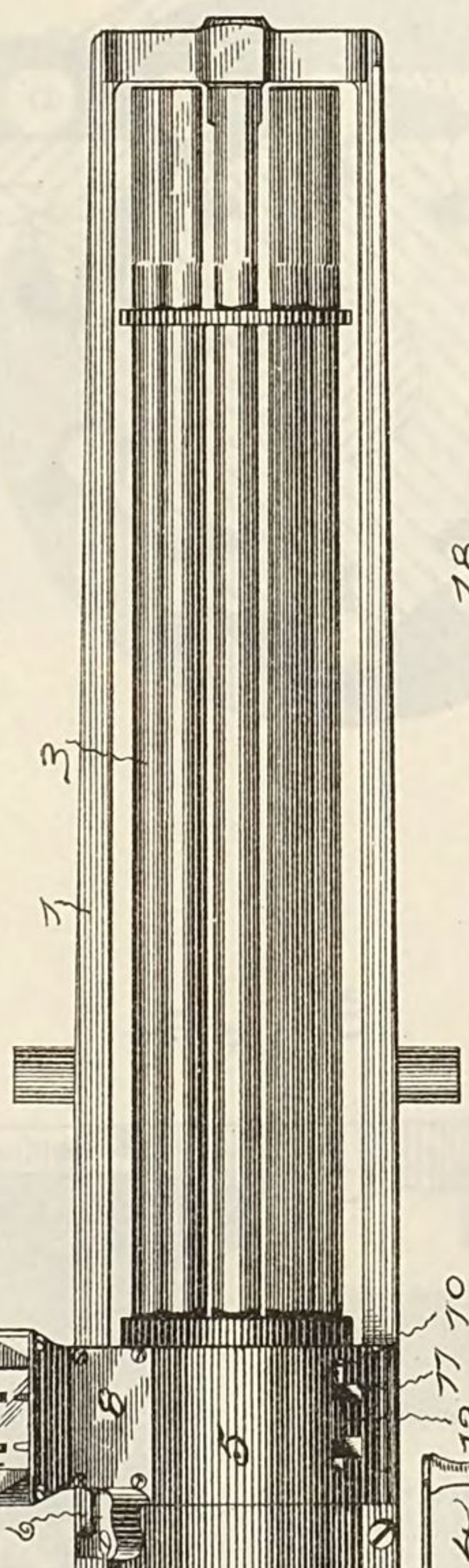


Fig. 1.

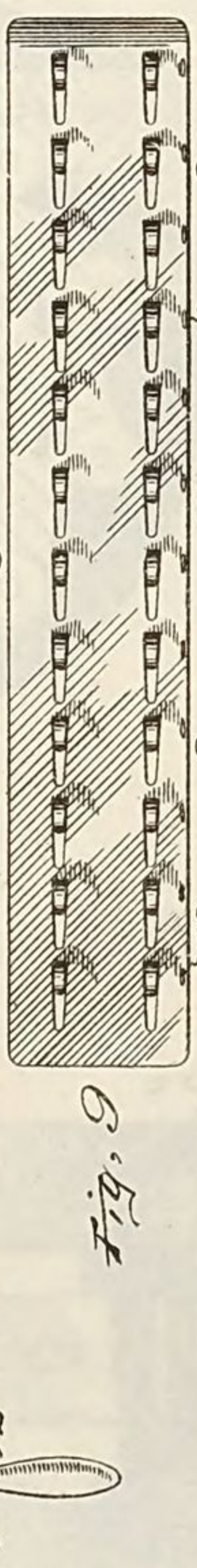


Fig. 9.

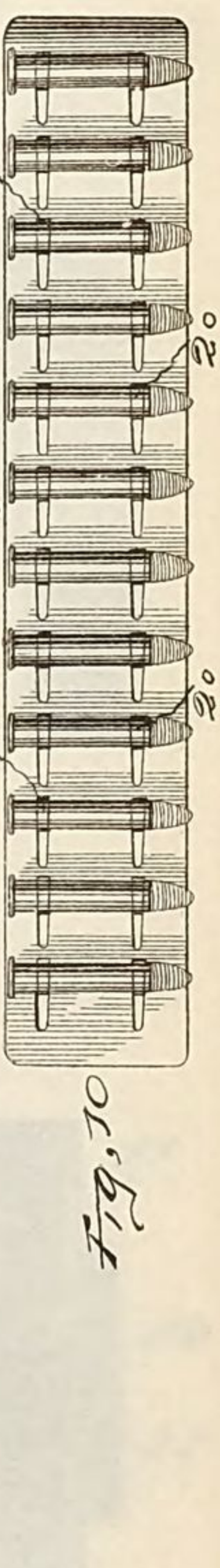


Fig. 10.

SECTION AND PLAN OF HOPPER

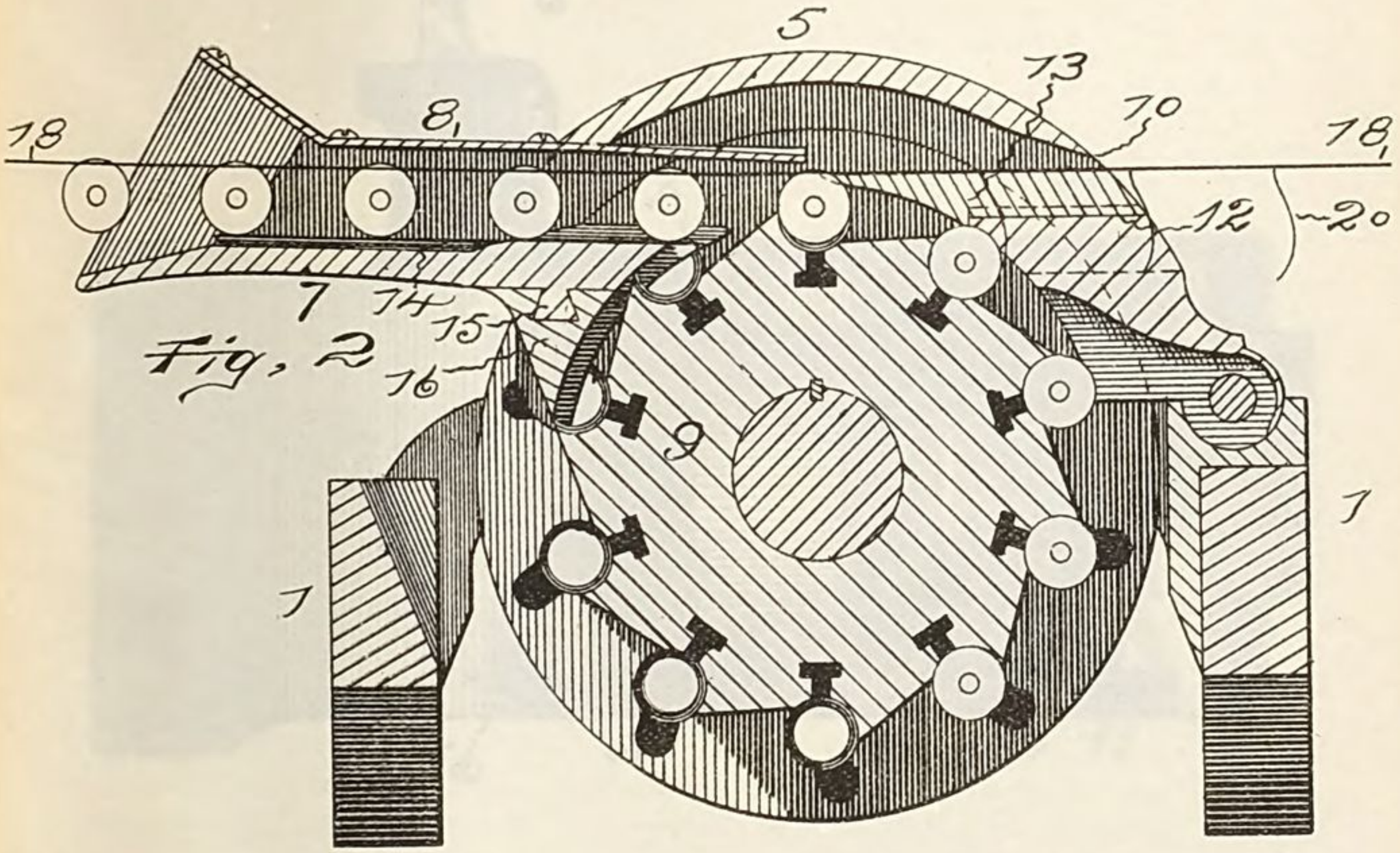


Fig. 2

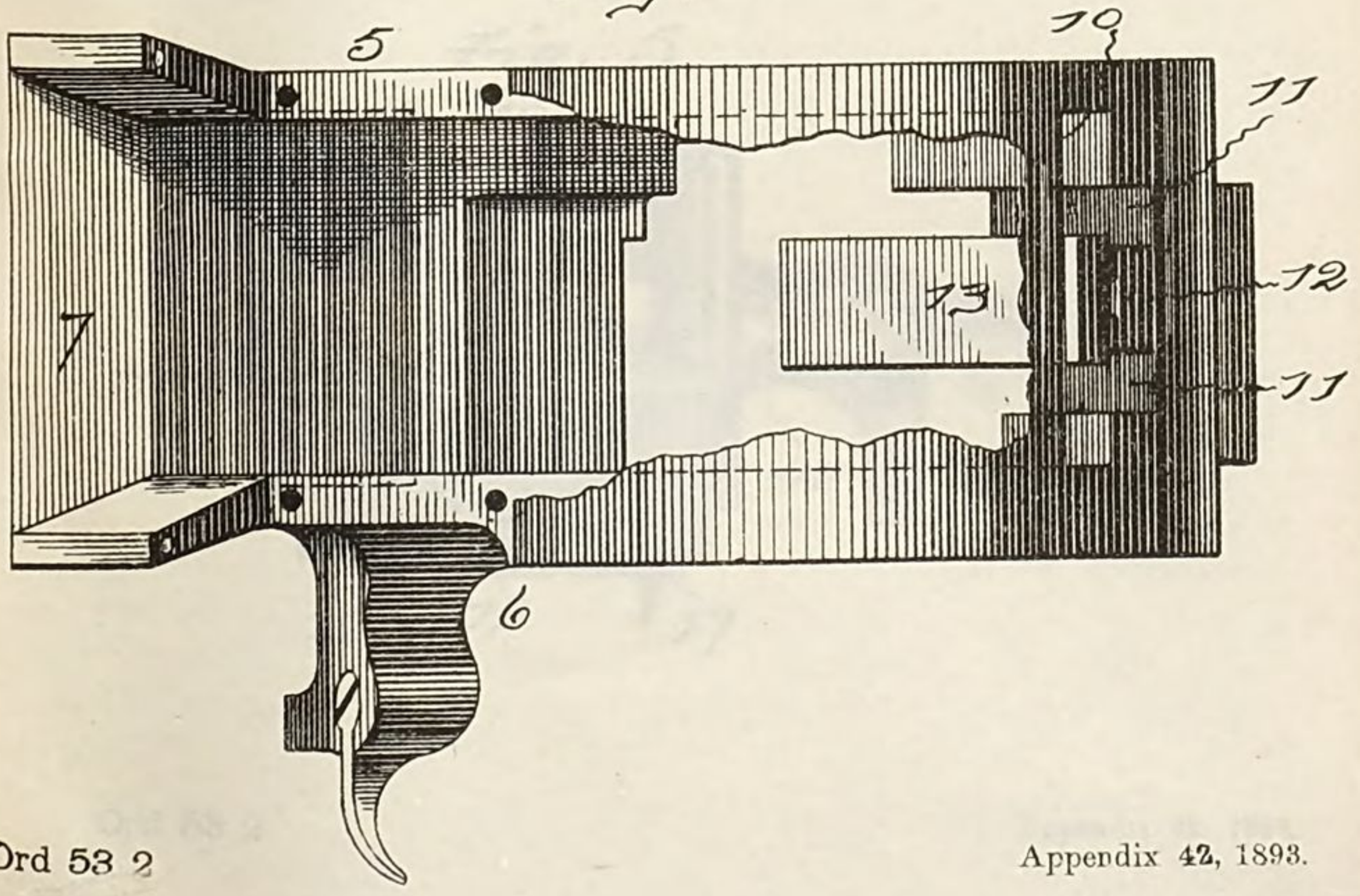


Fig. 3

BOTTOM AND SIDE VIEWS OF HOPPER.

Fig. 4

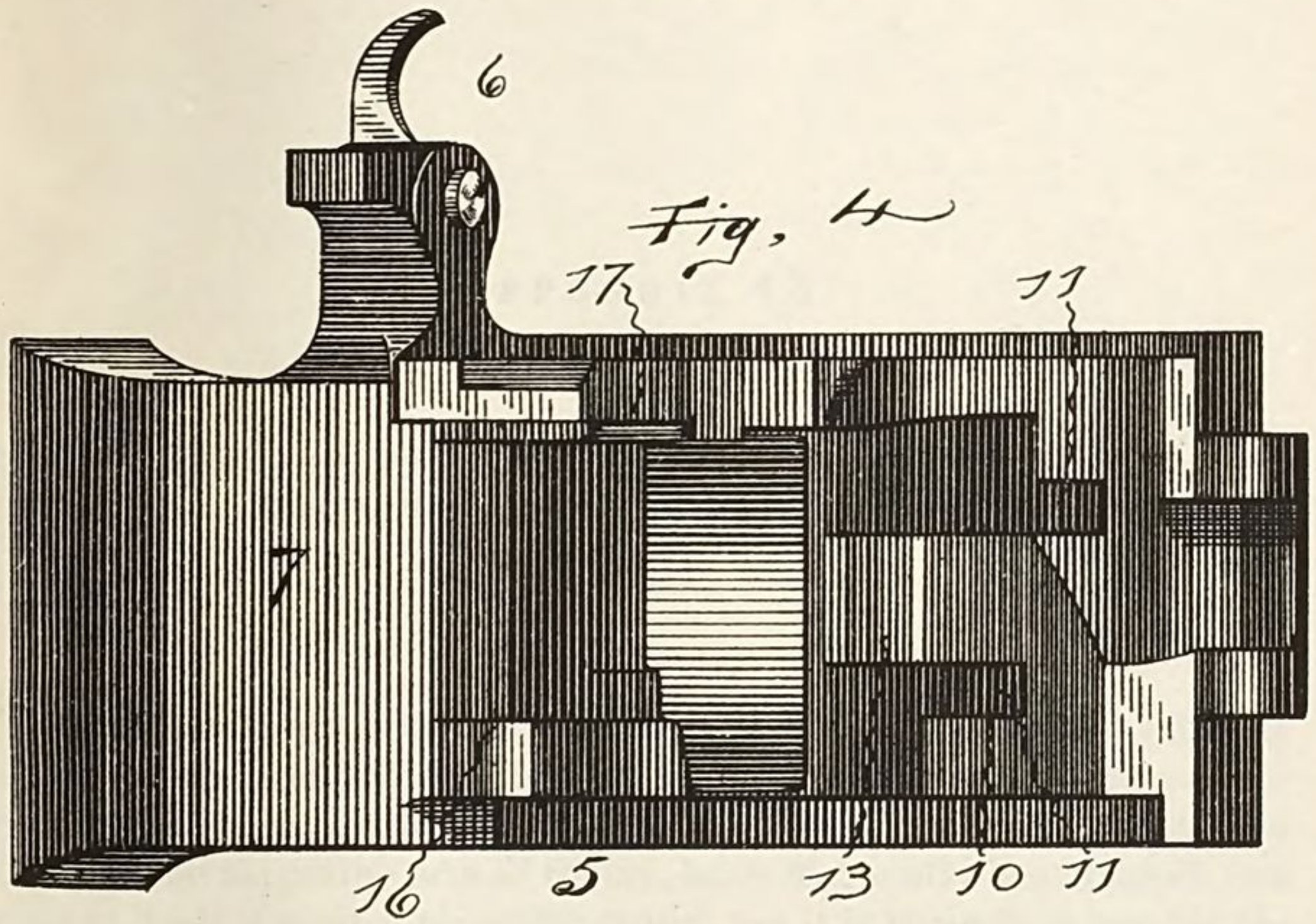
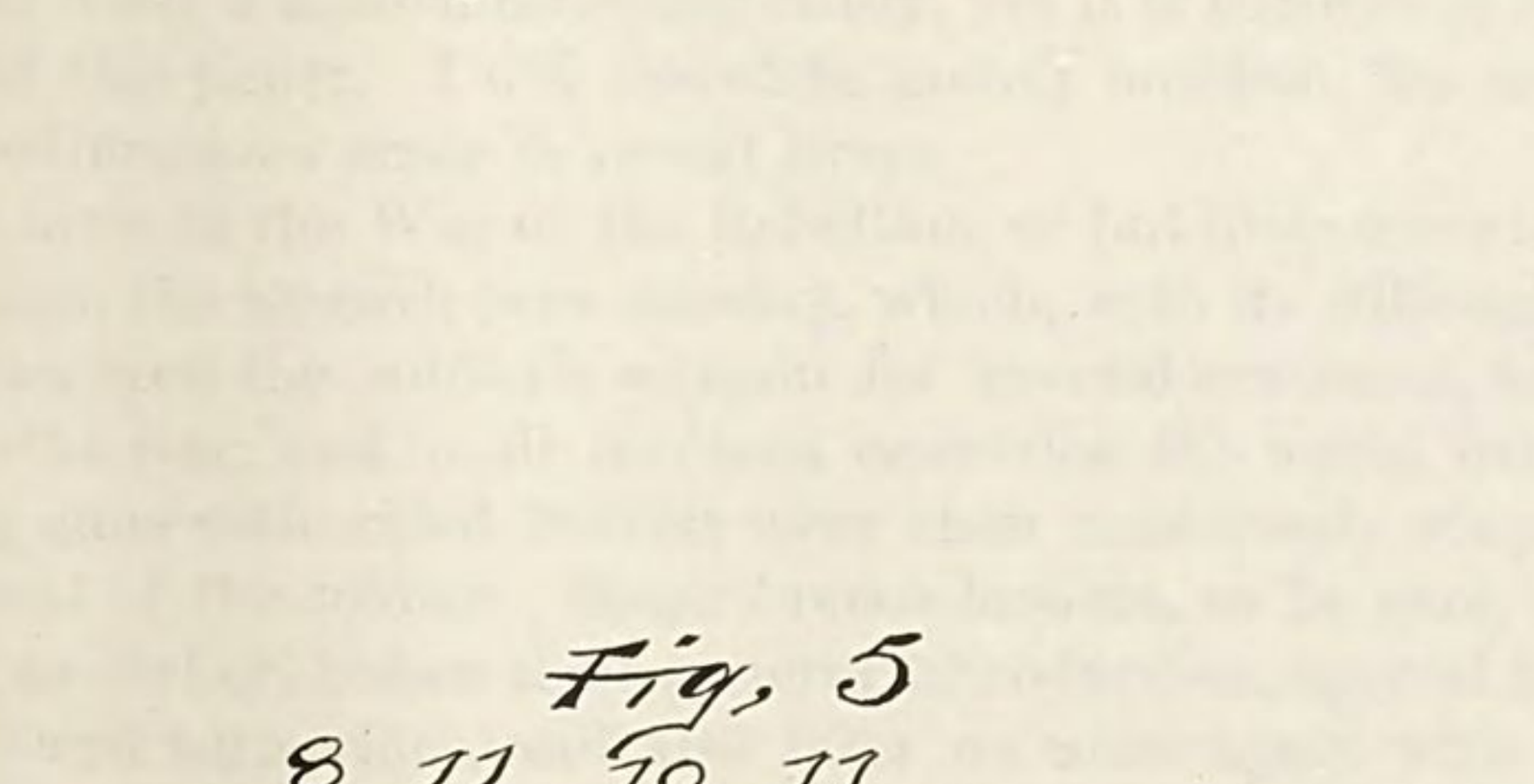


Fig. 5



APPENDIX 43.

THE MODERN INFANTRY RIFLE. BY CAPT. STANHOPE E. BLUNT, ORDNANCE DEPARTMENT, U. S. ARMY.

(3 plates.)

PART I.

The various steps in the development of the weapon of the infantry soldier, from the matchlock through the flint and steel, and the percussion smooth-bore, to the muzzle-loading rifle, the breech-loader, and finally to the magazine arm of to-day, have frequently been traced, and while in itself a most interesting study, yet it is somewhat beyond the scope of this paper. I will therefore merely mention the more important modifications made in recent times.

Just prior to the War of the Rebellion, or but little more than thirty years ago, the smooth-bore musket, which, with its different forms of lock, had been the soldier's weapon for several centuries, finally gave way to the rifle, and in all civilized countries the world over muzzle-loading guns with rifled barrels were then universally adopted as the armament of the soldier. Some breech-loaders, to be sure, were then in use, as earlier, before their general introduction, special troops had been armed with rifles, and also later on were again with magazine guns, but in the hands of the mass of every army muzzle-loading rifles alone were found.

These new pieces weighed from 9 to 10 pounds, their caliber varied in the different countries between 0.55 and 0.70 inches, the weight of the bullets from 400 to over 700 grains, and of the powder charges from 60 to 90 grains. In the great majority of instances the initial velocity of the projectile was less than 1,000 feet per second.

One country only had then made any marked advance beyond the others. In Prussia the new needle gun, a breech-loader, had for some years been in use and its successes in the Austrian war of 1866 drew general attention to the breech-loading principle; which, when the paper shell of the needle gun had been replaced by the metallic cartridge case, was conceded to be a practical success and was at once universally introduced.

Each country adopted its own preferred system of breech closure, blocks, operated in various ways, or sliding bolts being the general systems.

In all, however, barrels were made of smaller caliber, varying from about 0.40 to 0.45 inches; the weights of the bullets were established at about 400 grains, and as the powder charge was kept approximately unchanged the initial velocity of the new weapons was increased to about 1,400 feet per second.

The weights of the different guns were not materially altered from those of the preceding muzzle-loaders.

Magazine guns, notably the Spencer and later the Henry, or, as it was afterwards called, the Winchester, were used to some extent during the Rebellion, and later during the Turkish war of 1877, while in Switzerland the Vetterli had been adopted and supplied to their troops; but, with these unimportant exceptions, no marked changes occurred in small arms until about six or seven years ago, when the great improvements then perfected led to a rearmament in all countries, which has already resulted, or soon will, in every army being provided with new weapons, of which the distinctive features are the magazine system, the methods of breech closure, the reduced caliber, and the improved cartridges. These features will first be considered in general terms and then a few of the more representative arms described in greater detail.

THE MAGAZINES.

First, as to the magazines: In the experiments of the years preceding the advance mentioned many magazines, varied both in form and location, had been considered, but all that have survived adverse criticism and are yet deemed to possess merit can be included in three general classes, dependent upon the position of the magazine, namely, those where it extends forward under the barrel, those where it is placed in the butt of the stock, and those where its position is central, or just in rear of the barrel.

In the first and second divisions of this magazine classification the cartridges are contained in a tube, with the bullet of one impinging against the head of another. This method is open to the objection that an accidental explosion may occur in case a primer protrudes or is unduly sensitive. In the new Japanese arm, the Murata, it is endeavored to overcome this defect by sinking below the general surface of the primer its central or vital portion, and by giving the bullet a blunt point.

Another defect is the probability of the bullet being driven in upon the powder charge if the arm receives much jolting in carrying or is brought heavily to the ground. In the old gunpowder cartridges, where the bullets were strongly crimped in the case, this was not so likely to occur, but with the lighter crimping general in the new cartridges, added to the abnormal chamber pressures developed by com-

pression of the smokeless powder the defect of the system becomes much more serious.

The operation of charging tubular magazines is slow and tedious, it being necessary to insert the cartridges one by one and push them, for their full length, into the tube, until they in succession catch beyond a stop—an operation of increasing difficulty as the long spiral magazine spring becomes gradually compressed to its limit.

The method of feeding from the tube to the receiver of the arm is occasionally uncertain; theoretically perfect if the mechanism is properly operated, but actually liable to fail to lift the cartridge if the soldier should retract the bolt slowly and easily, or else if the bolt is brought back with undue force to actuate the spoon carrier with such energy as to throw the cartridge clear out of the receiver.

If the magazine is held in reserve while a number of shots are fired rapidly as a single loader, the heat of the barrel will, in the case of magazines lying along it, melt off any lubricant deemed essential and therefore placed on the bullet. With such magazines also the balance of the piece changes as the number of shots in the magazine diminishes, producing an undesirable complication in the influences affecting accuracy of fire. This is also true, though to a much less extent, for tubular magazines located in the butt of the stock.

The tubular magazine in the butt has now entirely disappeared as a part of the regular armament of any nation, while the similar magazine lying beneath the barrel is found only in the Murata of Japan, the Krokpatschek of Portugal, the Lebel of France, and in the Norwegian rifle, pieces that in the mechanism of their bolts, as well as in their magazines, closely resemble each other.

CENTRAL MAGAZINES.

Systems, where the magazine is centrally located, sharing none of the disadvantages just enumerated as inherent to the tubular class, being simpler in construction, more positive in action, quickly charged or emptied, readily examined by the firer endeavoring to ascertain the extent of his reserve, and finally of less weight and bulk, have gradually been adopted by most nations, and several millions are now in the hands of troops. It is to their examination that attention will then be given.

Every arm of this kind can be placed in one of three general classes, the distinction being dependent upon the manner in which fire from the gun can be delivered.

First. Those arms which, while the magazine is charged, can not be used as single loaders.

Second. Those in which the charged magazine can be held in reserve while single-loader fire is maintained, magazine fire being, however, available at any moment.

Third. Those possessing to a modified extent the properties of both the first and second classes.

All three classes can be used with greater or less facility as single loaders whenever the magazine is empty.

In weighing the comparative merits of the first and second classes the decisive arguments are not those founded upon the mechanical principles of the systems, but rather upon the tactical features of their fire, the manner in which it is to be controlled and delivered.

With the first class, more properly called repeaters, continuous fire is much accelerated. The cartridges carried by soldiers in packets, generally holding five, are with the packet inserted by one motion into the magazine, of which the packet or charger then becomes an essential part, and without which the mechanism will not operate. After the packet has been emptied, it falls to the ground through an opening in the bottom of the magazine box, and is then replaced by another loaded packet.

As the motion of inserting the charger and its five cartridges occupies but little more time than required for loading a single cartridge directly into the chamber, and as the transfer by the bolt of cartridges from the magazine to the chamber is more quickly accomplished than charging singly, the repeaters will, for an interval of any length—say two minutes—maintain a considerably heavier fire than is possible from a single-loading arm. They will also fire a few more cartridges in such an interval than most of the magazine arms of the second class, where the operation of charging the magazine being performed by inserting single cartridges, or else stripping or feeding them from a loading clip, requires slightly more time than when both packet and cartridges are introduced directly into the magazine box.

Magazines of the second class vary considerably in the amount of time required to charge them. In such an arm as the Lee-Speed or Lee-Metford of England, where it is necessary to insert the cartridges one at a time, continuous fire as a magazine arm will be slower than if the weapon had been used as a single loader only.

But in others, as the Schmidt of Switzerland, or the new magazine rifle model of 1892 of the United States, where the cartridges can be easily and quickly transferred from chargers to the magazine, a continuous fire from the magazine can be maintained much heavier than if the arm were used as a single loader only, and of but slightly less intensity than with the best of the arms of the first class.

Used as single loaders only, fire from magazine arms of the first class is generally slower than from those of the second. This is occasioned by the absence (a feature inherent to the system) of a floor to the receiver, making it necessary to insert the bullet, and generally more than half the cartridge, into the chamber before closing the bolt.

In the second class the cut-off, or the form of the receiver, offers a good floor, and it is merely essential that the cartridge be dropped

thereon in front of the bolt, which then, when moved, carries it directly to the chamber, a much quicker operation than that of inserting the cartridge with the fingers.

With the first class of magazine arms, with the object of maintaining the fire discipline, it is intended that all fire shall be from the magazine; the cartridges are therefore carried both in the ammunition train and by the soldiers in the metal packets which, when introduced in the box, form a part of the magazine mechanism. After firing these packets are thrown away. Their use adds slightly both to the weight and bulk of the ammunition transported.

To glance at one of the mechanical features of this packet system it will be observed, though generally mentioned as the means employed for carrying the ammunition and quickly placing it in the magazine, that the packets are actually a part, and a very essential part, too, of the mechanism, and unless they are in good condition the gun can not be operated.

Made generally very light and of merely skeleton form; carried on the person of the soldier; exposed to blows, dust, and rust, they are easily damaged; and if twisted out of shape, or if the corners of the lips embracing the cartridges are bent up, the bolt will jam against them instead of pushing the cartridge into the chamber. In fact, the packet is one of the most essential, about the most easily damaged, and certainly the most exposed portion of the magazine, a combination of evils that ought to condemn the system.

Returning now to the use of these arms, it may be said that it being never contemplated to load with single shots no provision for doing so is made when supplying ammunition to the firing line; the leaders can therefore never tell whether their men have five cartridges or only one in their guns, whether the magazine must be recharged, or whether the extreme intensity of fire can be maintained in any sudden emergency.

The normal use of the second class being as single loaders, most of the ammunition is carried as single cartridges in the belt or cartridge box, but to facilitate rapid loading of the magazine a portion of the supply is put in metal chargers, which when used permit of the magazine being replenished with almost the rapidity attained in arms of the first class. These chargers are not an essential feature of the system, as the magazine can be loaded by successively inserting single cartridges, but not quite so rapidly as when the chargers are used.

The main advantage claimed for guns of this class is the reserve of ammunition always instantly available for the supreme moment of an action, the moral support which the knowledge of this reserve is presumed to give, and the restraint upon officers and men produced by the desire to retain it intact until the instant when its expenditure shall produce the greatest effect.

In guns of this class the reserve is kept in the magazine during single-

loading fire by means of the cut-off, as in the Lee-Speed and in the Krag-Jörgensen of Denmark; or as in the Schmidt and the new Spanish Mauser, by slightly lowering the filled magazine so that the moving bolt may pass over the cartridges without touching them.

The third class of magazines are generally used only as repeaters, like the first class. Most of their ammunition is carried in clips, which, however, unlike the packets of the first class, embrace only the heads of the cartridges, and do not enter into or form part of the magazine mechanism, the cartridges being by the thumb stripped from them to the magazine. The magazine can also be charged directly with single cartridges.

A modified single-loading fire can be maintained by firing the upper cartridge in the magazine, replacing it with another, firing that, and so on, retaining meanwhile the balance of the cartridges intact. It is evident, however, with this system that it is possible the soldier in the heat of action, seeing a cartridge before him and forgetting to insert the fifth (the normal contents of the magazine), may encroach unintentionally upon his reserve, and at the decisive moment, therefore, find himself with only three or four or perhaps even a less number of cartridges at hand.

The system used as a means of securing a reserve possesses other defects and is merely a compromise; its inventors claim but slight merit on that account, which in fact is but the result of the peculiar method followed in charging the magazine, and for the armies where it is adopted (in Belgium, the Mauser; the Turkish gun of almost the identical design, and the new Russian rifle), the ammunition supply is put up in the clips, so issued to the firing line, and the magazine only actually employed.

From a supply of single cartridges magazine fire can be delivered with this third system, as it also can from the second, while in guns of the first class ammunition is useless for magazine fire unless the packets are also supplied.

The third class can then, as far as regards their general use, be included with those of the first system, resolving the general division into but two classes, those intended for use as repeaters and those where a reserve of ammunition is provided.

Stating concisely the facts concerning these two divisions, it may be said that for a prolonged period the more rapid fire can be delivered, if the arms are used as single loaders only, from those of the second class; if used as magazine arms only, from those of the first class, but that this latter excess is but slight when compared with the better systems of the second class.

With the first class, all fire being normally from the magazine, it is possible that at the very moment when the highest rate is most desired the soldier may find his gun either entirely empty or with but a portion of the packet's contents remaining.

The normal use of guns of the second class being as single loaders, with the magazine always retained as a reserve for the critical moment, this contingency should be avoided.

It is, however, probable that the proper use of the second class demands a higher training and better state of discipline than is necessary for the repeaters; and it is possible that the soldier in the excitement of action may, firing before the proper time from the magazine, find himself when it is most required without his reserve and without the moral support which its presence is presumed to afford.

With these premises the arguments pro and con upon the merits of the two systems of fire have been advanced by many able writers, soldiers of vastly greater experience than the present writer, and no effort will now be made to prove either system the superior of the other.

It is believed that the weight of opinion among officers of our Army inclines toward the reserve of ammunition, and a gun upon that system was last year recommended by a board of officers for adoption and is now in process of manufacture for the service.

Systems providing this reserve are now also the official weapons of Denmark, England, France, Japan, Portugal, Spain, and Switzerland; while in Austria, Belgium, Germany, Holland, Italy, Roumania, and Russia guns of the repeating type form the armament of their soldiers.

BREECH MECHANISMS.

Turning now from the magazine to an examination of the breech mechanism, it may be noted that while with the earlier magazine arms various means of closing the breech were devised, yet the developments of the last few years have shown a bolt of some form, particularly for arms of the reduced caliber using smokeless-powder cartridges, to be much superior to any other method, and all the arms now in the hands of troops are therefore constructed on this system.

In the breech mechanism and its action four principal points of difference can be noted, viz, the manner of moving the bolt; the method of locking it to properly sustain the shock of discharge; the arrangement and action of the extractor with reference to the body of the bolt; and the time in the movement of the bolt when the mainspring is compressed, and the method by which it is accomplished.

With three guns, the Mannlicher rifle and carbine of Austria and the Schmidt of Switzerland, the operating handle is only moved directly forward and back in opening and closing the bolt. In the Mannlicher rifle no part of the bolt rotates, but in the carbine and in the Schmidt an interior part of the bolt, including the locking lugs, does revolve, the motion of the handle being, however, kept direct. In the magazine rifles of every other country the bolt is operated by first giving it a quarter-turn to the left and then drawing it directly back; reversing these operations closes the bolt. The advocates of the direct motion claim for it the more rapid action, and that it is not necessary to remove

the piece from the shoulder while emptying the magazine, thus securing great intensity of fire at the critical moment.

But this system requires the application of force, somewhat in the nature of a blow, to start the bolt after firing, tending to disarrange the aim and compelling the soldier to catch it again before the second shot, while if the gun has been lowered to operate the bolt, aim is obtained almost instinctively as the piece is raised, and more quickly and accurately than if the gun had been wabbling around against the firer's shoulder while he was trying to manipulate the mechanism. This blow required with the straight action must also be increased as the gun becomes foul and hot.

If the sole object is to fire the greatest number of shots, the straight action, it is conceded, would possess merit if, which however is not possible, the gun remained clean and cool during firing, but if it is intended also to deliver the shots with any accuracy, it is the writer's experience that the turning bolt of such guns as the United States magazine rifle, model 1892, or of the Holland or Roumanian Mannlicher, is superior.

Bolts are locked either by lugs at their forward end engaging in channels in the front of the breech casing, forward of the receiver and immediately in rear of the chamber, or by lugs, blocks, or ribs, usually midway back on the bolt, which are supported at the moment of discharge by shoulders in the receiver or on its sides.

In the first variety the thrust to the rear is sustained just where it is applied by only one part of the bolt, and all behind that point can be made lighter or the well of the bolt can be bored to a greater diameter, permitting the use of a larger firing pin and stronger mainspring. In the second form the force of discharge is transmitted along the length of the bolt, which, to have sufficient strength to sustain it and to obviate any tendency to buckle with the consequent binding, must be made of greater exterior diameter and weight, or must sacrifice some of its interior cavity and lose thereby the strength in pin and spring possible in the first form.

The advantages of front-locking lugs are generally recognized, and all the more recent of the modern guns are so arranged, locking farther back or to the rear being retained only in the Lee-Speed, the Schmidt, the Mannlicher rifle of Austria, the Kropatschek, the Lebel, and the Murata.

In the majority of the new guns the extractor does not partake of the bolt's rotation, retaining always the first hold taken upon the cartridge.

This may be accomplished by the use of a bolt head fitting into the body of the bolt, but in a separate piece, and to which the extractor is secured. This plan, however, necessitates the weakening of the bolt and also of the head by the combination of grooves and ribs attaching them together, a result not so important when the head is very short and the locking lugs thus brought nearer the front, but of greater moment when the system locking farther to the rear requires both strength and stiffness in the bolt and head for smoothest working and greatest stability. A detached bolt head also renders the mechanism more suscep-

tible to the influence of dust and dirt, and may consequently require increased force for its operation. Another method of securing a nonrotating extractor is to give it a long shank, attached at the rear to a sleeve, embracing the firing pin and a rib on the body of the bolt, which is free to rotate under it. This latter method admits of having the entire bolt in one piece, securing simplicity of construction and a maximum of strength for a minimum of weight; the extractor itself can also be made much more powerful.

The mainspring is generally compressed, either by the manner the mechanism operates as the bolt handle is raised and lowered, or it is accomplished in greater part as the bolt is pushed forward in the act of loading the gun, the nose of the sear engaging upon a notch in the cocking piece and holding the pin as the bolt body passes over it to its seat.

By the first means the force the operator exerts is assisted in its application by the action of an inclined plane or cam on the rear of the bolt, and but little exertion is required. In the second case the bolt must be pushed forward directly against the power of the mainspring, a matter of but little moment for a few shots only, but of considerable importance when a number are rapidly delivered, as it then tends to lame the soldier's hand. Moreover, if after the spring is nearly compressed, but the handle not turned down, the bolt is then released, it will, under the action of the mainspring, fly back, possibly past the head of the next cartridge in the magazine, which will then rise part way in front of the bolt, and, with that already in the receiver, cause a jam of the mechanism as the bolt is returned; an accident very unlikely to occur if the piece is cocked by the means first mentioned.

Very few of the magazine arms now in service have the half-cock notch common to the older guns, but are, instead, provided with a safety lock which permits of the piece being carried loaded, but with the entire mechanism secured.

In case of a misfire it is necessary with most of the guns to recock by operating the bolt. With others, as the model 1892 of the United States, the Lee-Speed, the Schmidt, and though less easily in the German infantry rifle, this can also be accomplished by directly grasping the rear end of the firing pin and pulling it back to the full-cock position.

CALIBER—SMOKELESS POWDER—BULLETS.

Up to 1836 the calibers of the different guns ranged from 0.40 to 0.45 of an inch. Now they are about 0.30″, with some few as low as 6.5 millimeters (0.256″).

Formerly lead bullets of 400 grains or heavier and a gunpowder charge of about 70 grains were used. Now the bullet, a leaden core coated with some harder metal, weighs about 220 grains, some even as low as 165 grains, and the charge of only 30 to 40 grains is of a powder producing but little if any smoke upon discharge.

These radical changes are all sequences of the general introduction of magazine arms, though worked out simultaneously with the magazine problem, for the vastly increased expenditure of ammunition that would follow the adoption of the rapid-fire guns was acknowledged at the outset by all military men.

To provide the soldier with more cartridges without increasing the load he had to carry, it was essential that the diameter of the bullet, and consequently of the bore of his rifle, be diminished, and with that end in view experiments have been conducted for some years.

When gunpowder was used in these small bores it was observed that the fouling soon became excessive, impairing the accuracy of fire to an unallowable extent.

To overcome this the nitrate powders were then resorted to, where the products of combustion being entirely or mainly gaseous, the solid or unconsumed residue is very small, and the smoke produced upon discharge almost nothing; generally only a slight puff being noticeable, and that dissipating almost immediately.

A great variety of these powders have been successfully developed and are now in general use; their range of chamber pressure is considerable, running from 14 or 15 tons per square inch, as in the powders used in the French Berthier and the Schmidt, to 20 tons in the Belgian Mauser, and 21 tons in the German infantry rifle. This necessitates a strength and stiffness in the breech mechanism of the new rifles that the old arms did not require, and also a corresponding increase of strength in the barrel. The modern barrels are consequently generally made of a superior grade of steel and of a little greater thickness of metal. Being, however, of less interior diameter, and also somewhat shorter, their weight, as compared with the old, has been diminished.

With the augmented pressure also comes a great gain in the initial velocity, necessitating, in order to secure steadiness of flight for the bullet, a more rapid twist to the rifling, which now makes, in all the new guns, one turn in about 8 or 10 inches, instead of the 18 to 24 inches in the rifles of ten years ago.

The majority of the barrels are rifled with four grooves (though some have only three and others six or seven), of a depth varying in the different countries from 0.003 to 0.006 inch, and more frequently of a width two or three times that of the lands.

As leaden bullets fired with high velocities through such barrels will not follow the rifling, but will strip and override the lands, it became necessary that the surface of the projectile be made of some harder metal, but to retain the high specific gravity of the lead, with the consequent ability of the ball to better overcome the resistance of the air, the greater portion of the bullet was made of a lead slug and then coated or jacketed with a covering, about 0.02 inch thick, of some harder metal—as steel, copper, nickel, or German silver.

The soft lead bullet of the old rifle was made of about the same or even less diameter, than the bore, and then under the effect of its inertia and the blow produced by the combustion of the charge was set out into the grooves of the rifling.

With the modern bullets the maximum diameter exceeds that of the bore by a difference nearly equal to double the depth of the grooves, and the bullet is forced through them rather than set out into them.

These bullets have now a length of about 4 calibers, are without the cannelures or the lubricant of the lead ball, and weigh in the majority of instances about 220 grains.

The weights of the smokeless charges vary with the particular powders. They average, however, between 30 and 40 grains, and, unlike the gunpowder charges they have succeeded, do not usually fill the shell or, if the bullet in some cases does rest upon the charge, it is without giving it any compression. The necessity of regularity in the powder space and uniformity in the degree of crimp given the bullet in the cartridge case is more marked than with gunpowder, slight changes affecting considerably both the chamber pressure and the initial velocity.

The degree of heat produced by discharge is much in excess of that formerly evolved; it is also augmented by the friction developed in forcing, as previously mentioned, the harder bullets through the barrel, and as these two causes act more frequently than formerly, the rapidity of fire of the magazine arms being so much higher, the small caliber barrels now become so hot after a few discharges—not more than a dozen if rapidly delivered—that they can not be freely handled by the soldier.

To overcome this difficulty the Germans have enveloped the barrel in a metallic case secured with the barrel to the receiver and extending close up to the muzzle, where it embraces, but is not rigidly connected with, the barrel, which is then free to expand within it. Between these two points the barrel and the envelope are not in contact and the latter remains comparatively cool during firing.

The Swiss have incased the whole barrel in wood until it appears as if entirely surrounded by the forestock; but most of the other countries have limited the wooden hand guard to the space back of the rear sight, or else extended it only as far forward as the lower band. The latter provision is probably the best, affording all the protection required when firing or when carrying the piece afterwards.

PENETRATION—VELOCITY—ACCURACY.

The penetration at all ranges has been increased by the alteration in the shape of the bullet, by its harder surface, and also, except at the greater distances, where the air resistance will have overcome some of the velocity, by its more rapid initial movement.

At the shorter ranges, 200 to 300 yards, protection is now afforded by about 0.2 inch of steel plate and about 0.3 inch of wrought iron. The penetration into earth at these distances is about 25 inches, into pine about 30 inches.

As they have not yet been used to any extent in warfare their effect upon the living human body is yet to be determined. Upon cadavers and bodies of horses, mules, etc., many experiments have been made. It is certain the bullets, if striking no bone, will inflict wounds on three or four men if standing in file. Probably these flesh wounds would be less serious than those from the heavier lead ball.

In regard to the shattering effect on bone there appears to be a conflict of opinion among medical men, which only a war can settle conclusively.

With the greater number of the guns and cartridges the velocities are about 2,000 feet per second, running up for the smaller calibers, as the new guns of Italy, Holland, and Roumania, to about 2,300 feet per second; but for all the variations in any one gun, shot for shot, much exceed those obtained with the old lead bullets and gunpowder.

From the standpoint of a marksman the new weapons will not prove as satisfactory target guns as those they replace, but as judged by the soldier on the battlefield they must be considered vastly superior. This high initial velocity gives a dangerous space in front of the muzzle of fully 600 yards, a maximum even exceeded by the extremely reduced calibers just mentioned, and the flat trajectory at longer ranges compensates for errors when estimating the distance of the objective that would produce a miss with the old weapons.

The complete cartridge now weighs about six-tenths that of an old gunpowder cartridge, and as the modern guns are enough lighter than the old to fully counterbalance the additional equipment needed for the transportation of more ammunition, the soldier will be able to carry 175 rounds of the small cartridges without an increase of the load formerly put on him with 100 of the larger caliber.

SIGHTS—BAYONETS.

From what has been said of the flat trajectory and but relative absolute accuracy of the modern arms, it might have been inferred that the sights placed upon them would be thoroughly practical, designed for use in action, and to meet only the requirements that then arise. They are strong and simple in construction, with an open leaf that allows an unobstructed view when aiming, and without any arrangement giving a drift or windage correction.

The lowest adjustment is generally 300 meters (or yards), the leaf for that range being turned down on the base. Above that, on the leaf, the graduations are placed only for 100 meter (or yards) intervals, and with many of the sights it is impossible to obtain any closer adjustments

than given by these limits, the slide engaging in notches, that occur only at the graduation marks. The leaf gives ranges up to 1,800 or 2,200 yards (or meters), and for distances beyond that on some of the guns special long-range sights are provided. With the Lee-Speed, Mark I of England, these extend up to 3,500 yards.

The aiming notch is generally V-shaped, the peep or aperture sight not being found on any of the modern guns.

Front sights are all strong and heavy, with inclined, not vertical, sides.

For the familiar triangular bayonets all nations except Russia have now substituted knives, the forms differing somewhat for the different guns, yet all much alike.

The blades vary between 9 and 12 inches in length and are about an inch wide. The guards are short and usually straight, the handles of wood and steel and about 4 inches long.

The weights of the complete knife bayonets are between 8 and 15 ounces. The methods of attachment to the barrel are simple and strong.

Having now enumerated the principal features of the modern infantry rifles, I will explain some of the breech and magazine mechanisms in greater detail, selecting for that purpose one system of the repeater class, the new Mannlicher Model 1891 of Roumania, and the Model 1892 of Holland, and two having magazines in reserve, the Lee-Speed Mark I of England, and the magazine Rifle Model 1892 of the United States; the latter of these last two having a continuous bolt, forward locking lugs, and a mainspring compressed only by the rotation of the bolt—the former with a separate bolthead, rear locking lugs, and a mainspring compressed mostly by the direct push forward of the bolt.

The Mannlicher, especially the Holland arm, I consider the best of all the repeating class—the Model 1892 of the United States the best of the class where the magazine can be held in reserve.

In 1890 a board of officers was convened in this country to recommend a suitable magazine system for rifles and carbines for the United States service. From the descriptions in their report, prepared by the present writer for the board, of which he was a member, I shall quote extensively. For those who care to extend their study to include the small arms of the remaining continental powers I would suggest reference to the Report of the Chief of Ordnance U. S. Army for 1892, where in the proceedings of the board descriptions of the arms will be found. A table giving the main features of the different arms is, however, herewith appended.

Infantry rifles of different nations.

Nation.	Name of gun.	Type.	Magazine.	Cartridges in magazine.	Barrel.		Grooves.				Weight.				Kind of powder.	Initial velocity.
					Length.	Caliber.	Number.	Depth.	Width in terms of lands.	Twist.	Gun.	Bullet.	Powder.	100 cartridges as carried.		
					Inches.	*Inches.*		*Inch.*		*Inches.*	*Lbs.*	*Grains.*	*Grains.*	*Pounds.*		
Argentina	Mauser, 1891	Repeater	Central	5	29.1	0.301	4	0.003	2⅓	9.84	8.8	211	41	6.30	Smokeless	2,120
Austria	Mannlicher, 1888	do	do	5	30.1	.315	4	.008	1¼	9.84	10.1	235	40	7.16	Schwab-Rubin	2,060
Belgium	Mauser, 1889	do	do	5	30.7	.301	4	.003	2⅓	9.84	8.8	216	43	6.41	Wetteren	2,170
Bulgaria	Mannlicher, 1888	do	do	5	30.1	.315	4	.008	1¼	9.84	10.1	235	40	7.16	Smokeless	2,060
Chili	do	do	do	5	30.1	.315	4	.008	1¼	9.84	10.1	235	40	7.16	do	2,060
Denmark	Krag-Jörgensen, 1889	Cut-off	do	5	32.9	.315	6	.006	2	11.81	9.5	235	76	7.00	Black	1,770
England	Lee-Speed, 1891	do	do	10	30.2	.303	7	.004	5	10.00	9.4	214	66	6.50	Black; Cordite	1,830
France	Lebel, 1886	do	Tubular	8	31.5	.315	4	.006	2	9.49	9.3	231	46	6.15	Poudre B	2,050
Do	Berthier, 1891	Repeater	Central	4	.....	.301	4	.006	2	9.45	8.5	205	33	6.30	Smokeless	2,130
Germany	Model 1888	do	do	5	29.1	.311	4	.005	3	9.45	8.5	226	38	6.83	Nobel	2,050
Holland	Mannlicher, 1892	do	do	5	31.1	.256	4	.....	(a)	7.87	9.1	165	36	5.43	Smokeless	2,300
Italy	Carcano, 1892	do	do	5	28.8	.256	4	.006	.....	7.87	8.5	170	34	6.00	Balistite	2,320
Japan	Murata, 1887	Cut-off	Tubular	8	29.6	.315	4	.004	Equal.	11.00	9.0	238	36	6.69	Smokeless	1,850
Portugal	Kropatschek	do	do	8	32.3	.315	4	.004	Equal.	11.00	10.2	245	70	7.70	Black	1,760
Roumania	Mannlicher, 1891	Repeater	Central	5	28.6	.256	4	.....	(a)	7.87	8.7	165	36	5.43	Smokeless	2,260
Russia	Mouzin, 1891	do	do	5	.....	.300	4	.....	.....	9.00	9.5	213	33	6.12	Kazan factory	2,100
Spain	Mauser, 1891	Cut-off	do	5	.....	.295	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Switzerland	Schmidt, 1889	do	do	12	30.7	.295	3	.004	(a)	10.63	10.4	215	30	6.53	P. C., 1889	1,920
Turkey *	Mauser, 1890	Repeater	do	5	28.4	.301	.....	.....	.....	.....	8.8	213	41	6.34	Smokeless	2,110
United States	Model 1892	Cut-off	do	5	30.0	.300	4	.004	3	10.00	8.7	220	37	5.86	Wetteren	2,000

* It is reported that Turkey has just adopted the Krag-Jörgensen gun of the same model as the United States arm.
a Nearly equal.

PART II.

THE SMALL ARMS OF ROUMANIA, ENGLAND, AND THE UNITED STATES.

MANNLICHER (ROUMANIA AND HOLLAND).

(PLATE I.)

This arm has been adopted for the army of Roumania and, with some slight improvements, also for the army of Holland. The caliber is 6.5 millimeters (0.256 inches).

The magazine lies under the receiver and holds five cartridges, which, with the packet containing them, are introduced through the receiver. There is no cut-off or provision for single-loading fire with the magazine held in reserve. The arm, therefore, belongs to the repeating type.

Unlike the two Mannlicher arms in use in Austria, in this latest model both the bolt and its handle rotate as the mechanism is operated, the direct pull back of the other Mannlichers not being a feature of the Roumanian rifle.

In the plate, Fig. 1 shows the action open and a packet just introduced into the magazine. In Fig. 2 the action is closed, some of the cartridges fired from the magazine and one ready for firing in the chamber.

Fig. 3 is a plan view of the receiver.

Figs. 4 and 5 give sections as indicated on Fig. 1. Figs. 9 and 10, sections on Fig. 2.

Fig. 6 shows the bolt as assembled when withdrawn from the gun, Figs. 7 and 8 being sections through the locking lugs and the rear face of the body.

Fig. 12 is a view of the firing pin.

Fig. 13 shows the magazine cartridge packet.

DESCRIPTION.

The receiver (Fig. 3) is very simple in construction, its walls being plain vertical surfaces slightly further apart in the forward portion (*a*, Fig. 3) than in the rear (*b*, Fig. 3), where the receiver is widened to take the cartridge packet (*d*, Fig. 2). To the right, a shoulder (*d*, Figs. 3 and 5) furnishes a bearing for the right locking lug (*d*, Figs. 6 and 7) of the bolt as it is drawn back; this shoulder continues to the rear, as a groove (*d*, Fig. 4) through the breech casing. The left face of the receiver is prolonged upwards, constituting a channel (*c*, Fig. 5); this also is continued through the breech casing (*c*, Fig. 4), giving the left locking lug (*c*, Fig. 7) of the bolt and the ejector (*b*, Fig. 6) their support. A groove (*h*, Fig. 3) in the tang permits passage of the stud (*s*, Fig. 1) of the cocking piece. Forward of the receiver on the interior of the breech casing are two inclined grooves by which the locking lugs are

cammed forward and into position in front of the locking shoulders (*a a*, Fig. 1) as the bolt is turned to the right.

The bolt shown assembled in Fig. 6 and in longitudinal section in Figs. 1 and 2 is composed of the body with its operating handle, the head, and the cocking piece. The body (*b*, Fig 1) is bored in its middle portion to receive the firing pin and its spring; back of them the channel is reduced, forming a shoulder (*c*, Fig. 1), which furnishes the rear support to the mainspring; at the front end is a cylindrical groove in which the stud (*a*, Fig. 11) of the bolthead engages. On the surface of the body, near the rear end, is a cam (*c*, Figs. 6 and 8), by which the cocking piece is forced back as the bolt is turned to the left, and the cut (*b*, Fig. 8) into which the spindle of the safety lock can be turned. At the forward end of the body are the two locking lugs (*c* and *d*, Fig. 7).

In this gun the bolt is retained in the casing and guided in its motion when drawn to the rear by the left locking lug and the ejector moving in the groove, before mentioned, and by the bearing of the right locking lug upon the right-hand surface (*d*, Fig. 3) of the receiver. In the new Holland gun further support has been given the bolt by the addition of a long guide rib extending from the base of the handle along the top of the bolt nearly to the rear of the locking lugs (or in Fig. 1 from the handle along the part *b* to about the point marked by A), thus considerably increasing its stability when in the position most liable to injury.

The bolthead has on its right-hand side a groove for the extractor (*b*, Fig. 11) and on the opposite side an undercut channel, in which the ejector (*d*, Fig. 11) is secured and operates. The shank (*e*, Fig. 11) embraces the flattened portion (*b*, Figs. 2 and 12) of the firing pin, and as the latter does not revolve during the movement of the bolt, the bolthead and the extractor and ejector have only a motion of translation in the direction of the bore as the mechanism is operated.

The cocking piece embraces the rear portion of the firing pin; its projecting arm (*e*, Figs. 1 and 6) slides over the body of the bolt and is the receptacle for the spring and spindle of the safety lock (*m*, Fig. 6). The cocking piece and bolt body are assembled by means of the mainspring and firing pin and the securing nut (*f*, Fig. 1) at the rear of the latter.

The extractor (*b*, Fig. 11) lies loosely in the cut in the bolthead, being there retained when assembled by the shoulder on its under side and by the body of the bolt; its rear portion (*f*, Fig. 11) constitutes a spring, bearing against the interior of the bolt.

The ejector (*d*, Fig. 11) is retained in its undercut groove of the bolthead by the screw (*c*, Fig. 11), which permits a slight movement in the direction of the axis of the bore.

The firing pin is in one piece and is composed of the conical point (*a*, Fig. 12); the flat portion (*b*, Figs. 2 and 12) which fits into the shank (*e*, Fig. 11) of the bolthead; the collar (*c*, Fig. 12) affording the forward support

to the mainspring; the cylindrical spindle (*d*, Fig. 12) for the mainspring, flattened at one side to the rear (*e*, Fig. 12), where engaging against a screw stud on the interior of the cocking piece it prevents any rotation of the pin and consequently of the bolthead.

The trigger, sear, and sear spring are shown and their action indicated by the drawing (Figs. 1 and 2).

The magazine is a box lying under the receiver and formed partly out of the guard plate. Above this box a corresponding cut in the stock completes the magazine.

The bottom of the box is open at the rear (*C*, Fig. 2) to permit the passage of the empty cartridge packet; the remainder is closed by the plate (*D*, Fig. 2).

The cartridge packet (Fig. 13; *d*, Fig. 2) holds five cartridges; it is retained in the magazine, when full or partly full, by the catch (*c*, Fig. 2) and its spring; pressure on the knob (*l*, Fig. 2) allows its removal.

The overturned lips (*a*, Figs. 9 and 13) of the packet secure the cartridges; the carrier lever (*n*, Figs. 2 and 9) actuated by the spring (*m*, Fig. 2) rises between the sides of the packet and lifts them up to the receiver until a portion of the head of the upper cartridge is in front of the bolt.

When the packet is empty it falls to the ground through the cut (*d*, Fig. 1) in the bottom of the box.

It will be seen from the action of this packet that it is just as essential a part of the magazine as the carrier lever or the magazine spring, and its absence, or any serious damage to it, will just as much prevent magazine fire as would the removal or breakage of the other parts mentioned.

After a cartridge has been fired the action of the mechanism is as follows:

Lifting the bolt handle turns the body of the bolt to the left, the cocking piece by its stud (*s*, Fig. 1), and that on the assembling nut (*f*, Fig. 1) lying in the groove (*h*, Fig. 3) of the tang can not turn, and consequently by the cam (*c*, Fig. 6) on the bolt body are forced to the rear. After the handle has about half completed its revolution the locking lugs begin to bear against the inclined grooves in the breech casing, which run into the locking recesses (*a*, Fig. 1), thus moving slowly back the entire bolt and starting the empty shell; as the rotation of the bolt is completed the nose (*f*, Fig. 6) of the cocking piece enters a slight recess in the rear of the bolt, which is to hold it secure as the bolt is withdrawn, retaining the compression already given the mainspring; at the same time the shoulder (*s*, Fig. 1) of the cocking piece passes over the nose of the sear.

Drawing the bolt to the rear removes the empty shell, the right locking lug (*d*, Fig. 6) sliding upon the right surface of the receiver (*d*, Fig. 3) and the left lug and the ejector running in the opposite groove (*c*,

Fig. 3). When the ejector meets the ejector stud (*e*, Fig. 3) it is driven forward to the position shown in *b*, Fig. 6, the nose (*n*, Figs. 6 and 11) pushing out the left side of the cartridge head, which, as its right side is held by the extractor, is rotated sharply to the right and clear of the receiver. When the shoulder (*h*, Fig. 6) abuts against the left locking lug the ejector stud (*e*, Fig. 3) then becomes in its action a bolt stop, limiting further motion of the bolt to the rear.

A cartridge packet can be then introduced, as shown in Fig. 1, or if a cartridge has already been fired from the packet, the next, under the influence of the carrier lever (*n*, Fig. 2), will rise until its head lies in front of the bolt.

Pushing the bolt forward drives this upper cartridge out of the packet into the chamber. When the bolt is nearly forward the notch (*s*, Fig. 1) of the cocking piece impinges against the nose of the sear (*s*, Fig. 2); then, as the handle is turned to the right, the locking lugs enter the inclined grooves in the front breech casing, camming the bolt slowly forward, seating the cartridge, and completing the compression of the mainspring. The final motion of the handle merely seats the lugs in the locking recesses (*a*, Fig. 1).

In the rotation of the bolt the cams on the bolt and breech casing thus produce the entire compression of the mainspring, start the empty shell, and fully seat the cartridge. By the direct motion of the bolt the shell is withdrawn and ejected and the new cartridge introduced.

In case of a misfire the piece can be recocked by turning the handle up and then back to the firing position without withdrawing the bolt; or, but not with so much ease, by grasping and drawing back the assembling nut (*f*, Fig. 1) of the cocking piece.

When the piece is cocked, moving the thumb piece (*m*, Fig. 6) to the right, throws the spindle of the safety lock into the recess (*b*, Fig. 8) in the end of the bolt, and locks the entire mechanism, permitting the gun to be carried loaded with safety.

If the trigger is pulled before the locking lugs are properly seated, the action of the nose (*f*, Fig. 3) of the cocking piece on the side of the cam (*c*, Fig. 3) of the bolt will throw the latter to the right, seating the lugs before the point of the firing pin reaches the primer.

LEE-SPEED, MARK I (ENGLAND).

(Plate II.)

This gun, known as Mark I, is of the pattern of those first issued for trial in the British service. The caliber is .303; the magazine, holding eight cartridges, belongs to the detachable type; having a cut-off, single-loading fire with the entire contents of the magazine in reserve is possible.

In the plate, Fig. 1 shows a longitudinal section and view from the right side when the bolt is entirely drawn back and the magazine full.

Fig. 2, the same in the firing position, magazine partly emptied.

Fig. 3, rear view of bolt, showing the handle bar and locking lugs in their positions in Fig. 1.

Fig. 4, section of bolthead and screw on B *b*, Fig. 1.

Fig. 5, longitudinal section of bolthead on A A, Fig. 6.

Fig. 6, rear view of bolt, showing the handle bar and locking lugs in the position in Fig. 2.

Figs. 7 and 8 give the top and end views of the dust cover of bolthead.

Fig. 9, section of magazine, spring, and follower, as in Fig. 1.

Fig. 10, section and rear view of receiver on C, Fig. 2, showing position of cut-off (when open), chamber, extractor cut, and mortise for top of magazine.

Fig. 11, section on D, Fig. 2, showing dust cover, guide rib, and locking lug in firing positions.

Figs. 12 and 13 show a side and top view of the magazine follower.

DESCRIPTION.

The receiver (Figs. 1 and 2, and in Fig. 10 section and rear view on C, Fig. 2) has a vertical slot cut entirely through it for the purpose of receiving cartridges from, or loading them into, the magazine.

Its right face is partly cut away, affording a shoulder for the guide rib (A, Fig. 1) of the bolt when locked and a guide for the bolthead. The left face is slightly curved to the shape of the bolt, with at one portion a short ramp to bring the cartridges into the axis of the bore as they are pushed by the bolt into the chamber. Towards the rear the right face is brought up to the level of the left, and together they embrace and direct the motion of the bolt and its long guide rib. Shoulders (*a*, Fig. 10) at the bottom of the receiver afford an abutment for the magazine, and a curved ramp (*r*, Figs. 1, 2, and 10) in front, a surface up which the bullet passes as the cartridge is pushed forward by the bolt. In the rear of the magazine slot is a spiral groove (*b*, Figs. 1 and 2), in which the lug (*c*, Fig. 1) on under side of the bolt engages, and behind that is a vertical slot to permit the sear to reach, and a guideway to direct the motion of, the cocking piece.

The bolt belongs to that class where the non-rotation of the extractor is secured by placing it in a separate bolthead; the head and the body together comprise the bolt. The body, cylindrical in general shape, is bored from end to end, the cavity being of three different sizes, largest at the front, to afford space for the shank of the head; smallest toward the rear, where only the body of the firing pin moves; midway is a shoulder, affording support to the rear of the mainspring when it is compressed.

On the under surface of the bolt is a lug (*c*, Figs. 1 and 11), which, with the opposite guide rib (*a*, Figs. 1 and 11), locks the bolt when in the firing position. It will be observed that this locking is accomplished at about midway of the bolt, the system belonging then to that class rather than to those where the shock of discharge is taken

up immediately in rear of the chamber. At the rear and at right angles to the bolt is the operating handle (*h*, Figs. 3 and 6), which lies close (Fig. 6) to the stock when the breech is closed. Near the handle two longitudinal grooves (*e*, Figs. 1, 2, and 6) are formed on the under surface of the bolt, united by a short inclined groove or cam; in these a stud (*d*, Fig. 2) on the cocking piece engages as the bolt is rotated.

The bolthead (*a*, Fig. 5), which does not rotate with the bolt, is connected with the body by a screw (B, Figs. 1 and 4), which, passing through the guide rib and body, engages in a slot (*b*, Figs. 4 and 5) in the shank. This method of joining the bolthead and body is objectionable, the screw often working loose or being broken in maneuvering the bolt.

In the Mark II, a pattern designed to overcome the defects of Mark I and since issued for trial, this screw has been omitted, the forward end of the well of the bolt body tapped, and the shank of the head threaded, thus causing, when the handle and the body of the bolt are turned, the head to slightly unscrew and not partake of the bolt's rotation, the projecting lip (*b*, Fig. 3) of the head, which engages over the undercut rail (*c*, Fig. 10) of the receiver, retaining it in place. The dust-cover limits the unscrewing of the head; removing the cover, the head can then be entirely unscrewed from the body.

Shank and head are pierced for the firing pin; the head is cylindrical and of the same exterior diameter as the body of the bolt, with a slotted rib for the extractor and spring corresponding to the guide rib of the bolt, and a lip (*b*, Fig. 3) to embrace the undercut rail (*c*, Fig. 10), which forms the outer surface of the right face of the receiver.

The firing pin is in one piece, the body (*f*, Fig. 2) cylindrical, the striking portion (*f'*, Fig. 2) gradually tapering to the point; a collar at the junction of the two affords the forward support for the mainspring when compressed, and limits the motion of the striker by impinging against the rear face of the shank of the bolthead.

The pin screws into the cocking piece and is prevented from turning or becoming unscrewed by a cut, in which a set screw (*a*, Fig. 2) engages.

The cocking piece (A, Figs. 1 and 2) has a milled head and a body of the same width as the guide rib and locking lug of the bolt; its front face (*f*, Fig. 1) constitutes the full-cock notch; it has a half-cock notch (*d*, Fig. 1). Like the bolthead, the cocking piece does not partake of the bolt's motion of rotation. The extractor and its spring (*c* and *d*, Fig. 5) lie, the latter entirely, the former mostly, within the slotted rib of the bolthead; when the bolt is closed the claw of the extractor enters the cut (*b*, Fig. 10) in the receiver.

In Mark I the dust-cover over the bolthead (Figs. 7 and 8) is a separate piece, and affords the upper bearing for the extractor spring.

In Mark II this part of the cover is omitted; the bearing for this spring is in one piece with the rest of the head, and is also somewhat strengthened.

The ejector (*g*, Fig. 1) is a stud formed by a screw, which, passing through the left side of the receiver, has its point projecting from the inner face.

The spiral mainspring, the trigger *t*, sear *s*, and sear spring *w*, which also serves as the spring for the magazine catch, are fully shown in Figs. 1 and 2.

The magazine (Figs. 1, 2, and 9) is a sheet-steel box, fitting in a mortice in the guard plate and stock, and abutting against the shoulders (*a*, Fig. 10) at the bottom of the receiver. On either side of the box are two corrugations (*g*, Fig. 2), forming guiding ribs, along which the cartridges roll as they are forced upwards by the magazine spring; the rear portion of the sides are slightly turned in, forming two lips, under which the heads are engaged in loading, and which retain the cartridges against the pressure of the magazine spring.

The platform or cartridge carrier (Figs. 12 and 13) is hollowed to form a bed for the cartridges, and has on either side a projection (*a*, Fig. 13), which slides along the forward guide ribs of the magazine. Two tongues (*b*, Fig. 12) are punched out of the bottom of the platform to afford an attachment for the spring.

The magazine spring is of wire, one end resting on the bottom of the box, the other caught around the tongues of the platform. A rib on the back of the box has a shoulder, in which a spring catch engages to hold the magazine in position; this catch is prolonged, forming a small trigger (*t*, Fig. 2) in front of the main trigger of the gun; if withdrawn, it permits the magazine to fall out by its own weight. A ring at the front, with a two-link chain, secures the box to the guard swivel.

In Mark II some improvements have been incorporated in the magazine. Its capacity has been increased from eight to ten cartridges, the increase being accomplished by broadening the box and at the same time decreasing its depth, the cartridges now lying more in echelon than in the first gun.

In Mark I, the box decreasing in width at the top, the successive cartridges issued through the same narrow opening into similar positions in the receiver; in Mark II, their echelon position is preserved, one cartridge rising in front of the bolthead to the right of the axis of the receiver, the next to its left, then to the right, and so on.

The platform or cartridge carrier (Fig. 13) has now been made in steps, its left side higher than the right; and for the wire spring (*g*, Fig. 2) a single curved spring of sheet steel has been substituted, one end secured by a lip over the front face of the magazine box, the other end embracing a bar forming trunnions, which play in elongated beds in ribs under the platform.

For the two-link chain, securing the box to the guard swivel, a single link has been substituted, which can not be so readily opened.

The cut-off (*d*, Fig. 10) is a flat plate pivoted near the front end and provided with a projecting thumb piece.

Supposing the gun to have been fired, the operations to remove the empty shell, reload, and fire are as follows: Immediately on commencing an upward pressure on the handle the stud (*d*, Fig. 2) on the cocking piece moving along the cam (*e*, Fig. 2) on the under side of the bolt withdraws the firing pin from the head of the cartridge; continuing the rotation of the bolt the locking lug enters the curved portion of the cut (*b*, Figs. 1 and 2) in the receiver and slightly cams back the entire bolt, starting the empty shell and continuing the partial compression of the mainspring. Drawing the bolt to the rear the half-cock notch and the face of the cocking piece pass over the point of the sear, and the extractor withdraws the shell until its head striking the ejector it is deflected to the right; continuing the motion to the rear, the bolt passes the head of the upper cartridge in the magazine, which then slightly rises until held by the latter's turned over lips; motion of the bolt is finally stopped by its head butting against the shoulder on the upper right face of the receiver. At this stage the position of the mechanism is as shown in Fig. 1.

Moving the bolt to the front it pushes the cartridge forward, the bullet rising along the ramp (*r*, Fig. 1) at the front of the receiver (this rising of the bullet is more marked as the magazine becomes partly emptied, its spring being then less compressed), the head sliding along under the lips of the magazine until passing them it rises smartly and engages under the claw of the extractor.

When the bolt reaches such a position that the cartridge is about four-fifths in the chamber the sear impinges upon the front of the cocking piece, preventing any further motion of the latter, and as the bolt is advanced giving additional compression of the mainspring.

The system is then an illustration of that class where the greater portion of the work of compressing the mainspring is thrown directly upon the soldier's hand.

The final compression of the spring and seating of the cartridge is accomplished by the camming of the locking lug in the cut in the receiver as the handle is turned down.

The position of the mechanism at this stage is as shown by Fig. 2. Pressure on the trigger rotates the sear, and freeing the cocking piece permits the striker to reach the primer.

The shock of discharge is transmitted along the bolt to the long guide rib and locking lug on its rear half and sustained finally by the shoulder and cut in the receiver.

Gas ports (*p*, Fig. 1) are provided at the right and left of the receiver and in the bolthead to permit the free escape of gas in the event of a ruptured cartridge head.

The breech mechanism is provided with a dust cover (longitudinal section in Fig. 2, cross section in Fig. 11), but except limited portions on the bolthead (Figs. 6, 7, and 8), which serve as the guide lip and as

a support for the extractor spring, the cover is not an essential feature of the system.

Grasping the milled head (*m*, Fig. 1) of the cocking piece with the thumb and finger the piece can be brought to either the half or full cock; in the first position the bolt can not be turned; the cocking piece must first be let down or else further retracted to the full cock. If when the bolt is withdrawn to eject the empty shell, the cocking piece be turned to the right, as by accident it readily can, or to the left, it will prevent the closing of the bolt.

A safety key, which engages in the notches *n* and *n*, Fig. 1, if opened when the bolt is closed and cocking piece down, locks the entire mechanism. It can not be operated when the sear is in the half notch.

If operated with the firing pin at full cock the bolt can be turned, but only partly withdrawn; operated when the bolt is further or entirely withdrawn, it prevents the bolts closing.

In Mark II this safety key and consequently the notches (*n*, *n*, Fig. 1) on the cocking piece have been omitted.

If the trigger is pulled before the locking lug and guide rib are fully seated the stud (*d*, Fig. 2) on the cocking piece will (depending on the amount of rotation of the bolt) either pass along the short longitudinal groove under the bolt or strike full against the part separating the long and short grooves, in either case the striker will not reach the primer; or else it will strike the inclined edge of this separating portion next the long groove and complete the rotation of the bolt to the locking position before the striker impinges on the primer.

In the trials of Mark I, this stud was often sheered off, leaving it possible to discharge the piece before it was fully locked. It has since been so strengthened as to overcome the defect.

As will be seen from the description, it is contemplated that for all prolonged fire the gun shall be used as a single loader, retaining the magazine in reserve, as once the magazine has been emptied its recharging is a very slow process, it being necessary to put the cartridges in one at a time.

Compressing the main spring as the bolt is closed requires more work for that portion of the motion, and its locking to the rear brings the strain where ultimately it may produce sufficient buckling to increase the difficulty of the other motion of the bolt. The two causes together make the mechanism one of the stiffest of the modern arms to operate.

MAGAZINE RIFLE, MODEL 1892, UNITED STATES.

(Plate III.)

This rifle is upon the Krag-Jörgensen system, and in some respects is the same as the arm of the Danish troops, but in many particulars has been modified and vastly improved for the United States service.

The caliber is 0.30 inches.

The magazine holding five cartridges is of the fixed type, horizontal, under and also to the left side of the receiver. The gun has a cut-off; the magazine can therefore be held in reserve while single-loading fire is conducted.

In the plate Figs. 1 and 2 are sectional views showing the mechanism assembled, the former after a shot has been fired and the empty shell ejected, the latter ready for firing.

Fig. 3 is a side view of the bolt assembled, the parts being as shown in section in Fig. 1.

Fig. 4 is a rear view of the bolt in the same position. The broken lines indicate the motion and position of the handle corresponding to the longitudinal section in Fig. 2.

Fig. 5, a rear view, and Fig. 6 a top view of the bolt body, removed from the assembled bolt.

Fig. 7, two views of the firing pin body.

Fig. 8, views of the striker.

Figs. 9 and 10, the cut-off spring and the cut-off.

Fig. 11, side and top views of the cocking piece.

Fig. 12, rear, side, and front views of the sleeve.

Fig. 13, rear and side views of the safety lock.

Fig. 14, top and left-hand side of extractor.

Fig. 15, extractor spring.

Fig. 16, main spring.

Figs. 17 and 18, cross sections of assembled bolt at the points indicated in Fig. 3.

Fig. 19, plan view of receiver with bolt removed, and of the magazine with gate open.

Fig. 20 is a cross section taken on AA, Fig. 19; and Fig. 21, one on AA, Fig. 19, except that the gate is shown as closed. Fig. 22 is a corresponding section taken with three cartridges remaining in the magazine.

Fig. 23 is a face view of the follower and carrier lever.

Fig. 24, two views of the lever spring.

Fig. 25, an interior view of the magazine gate.

DESCRIPTION.

The receiver and the magazine (except its side plate, *e*, Fig. 20) are formed solidly out of one single piece. They will, however, be described separately.

The receiver (Figs. 1, 2, 19, and 22) is bored through longitudinally for the reception of the breech bolt, and is also cut away on the right and partly on top to facilitate ejection of the empty shells and use of the arm as a single loader. Being closed on the bottom (*f*, Figs. 1, 2, 19, and 22), it affords a smooth surface on which the cartridges may be placed when using the arm in the latter manner. They are then carried forward by the bolt into the chamber. On the left hand an opening or longitudinal slot (*a*, Fig. 1) of less width at the rear than at the front

is cut, along and through which the cartridges pass from the magazine to the chamber, the motion of the point of the bullet being directed by the ramp *b* (Fig. 1). At the bottom of the receiver, at its forward end, is a recess (*k*, Figs. 1 and 19) for the locking lug (*k*, Figs. 2 and 6) of the bolt, and at the front end of the left-hand wall is a shoulder (*h*, Fig. 1) giving bearing to the front of the extractor spring. Forward of this a cut in the breech casing (*h*, Fig. 2) affords space for the upper surface of the extractor hook.

The rib (*a*, Fig. 22) and the ledge (*b*, Figs. 19 and 22) on right wall of receiver afford bearing for the locking lug (*k*, Figs. 3, 5, and 6) as the bolt is moved, and for its guide rib (*r*, Figs. 1, 3, and 6) when the bolt is in the firing position. The left wall of the receiver (*d*, *h*, Fig. 1; *d*, Fig. 22; *w*, Fig. 19) and the right face of the rear part of the breech casing (*t*, *s*, Fig. 19) also guide this rib and the bolt as it is withdrawn. The tang of the receiver has a groove (*l*, Fig. 19), in which the nose (*n*, Figs. 3 and 11) of the cocking piece moves, and which prevents its turning with the bolt. The under face of the receiver (*f*, Fig. 2; *a*, Figs. 20 and 21) forms the upper wall of the magazine. At the right of the receiver the curved shoulders (*t*, *s*, Fig. 19) of the breech casing serve to guide the rib of the bolt in its motion; its helicoidal surface, *s*, with the locking lug recess (*k*, Fig. 19) gives the bolt its slow final forward motion as the handle is turned down into the slot (*q*, Fig. 19); the rear face of this slot, and the lower plane face of *s* afford additional support to the bolt upon discharge in case the locking lug proper (*k*, Fig. 6) should give way. At the bottom of the receiver a mortise (*e*, *f*, Fig. 19) forms the receptacle for the ejector.

The bolt (Figs. 3, 5, and 6), with its operating handle (*h*, Figs. 5 and 6), is in one piece and is composed of the body (*d*, Figs. 3 and 6), the guide rib (*r*, Figs. 3, 5, and 6), and the locking lug (*k*, Figs. 3, 5, and 6). It is bored of uniform diameter except at the front, where a curved surface (*m*, Fig. 2) gradually closes it, permitting only the issue of the point of the striker (*m*, Figs. 1, 2, and 8). Below the handle the bolt is cut away, giving a warped or camming surface (*f*, Figs. 3 and 5) along which the nose (*m*, Figs. 3 and 11) of the cocking piece moves as the handle is turned upwards, and into the bottom of which (*c*, Fig. 3) it falls as the trigger is pulled. The base of the handle partly encircles to the left the body of the bolt in the form of a projecting collar (*b*, Figs. 5 and 6). In a notch (*a*, Figs. 5 and 6) the spindle (*a*, Fig. 13) of the safety lock enters when the mechanism is locked. A channel (*e*, Figs. 1 and 18) on the bottom of the bolt, extending up on the right side (*e*, Fig. 3) permits passage of the bolt over the heel (*e*, Fig. 2) of the ejector. This channel is stopped a short distance (*p*, Fig. 1) from the front face of the bolt.

The firing pin is composed of two parts connected by a ball and socket joint, the striker (Fig. 8) and the body (Fig. 7). To the rear of the body is screwed the thumb or cocking piece (Fig. 11), curved and

checked (*g*, Figs. 1, 3, and 11) to afford a firm hold for the thumb and fingers. On the lower side are the cocking cam (*m*, Figs. 3 and 11) and the cocking notch (*n*, Figs. 1, 3, and 11). On the upper side of the cocking piece is a notch (*l*, Figs. 1 and 11; *b*, Fig. 2) in which the body of the safety lock (*b*, Fig. 13) can be turned down to lock the gun.

Over the body (*b*, Fig. 11) of the cocking piece and over the body of the firing pin and fitting into the interior of the bolt is a sleeve (Fig. 12). The projecting arm of the sleeve is forked (*a*, Figs. 3 and 12) to receive the heel of the extractor (*a*, Fig. 14) which is therein retained by a screw (*o*, Figs. 1 and 3). A groove (*w*, Figs. 1 and 12) on the under side of the arm engages, when assembled, over the collar (*x*, Fig. 1; *b*, Fig. 6) on the bolt. A cut (*d*, Fig 12) permits the movement of the nose (*n*, Figs. 3 and 11) of the cocking piece. One side of this cut is beveled (*m*, Fig. 12) to afford an escape for dust or dirt as the nose of the cocking piece moves back along the cam (*f*, Fig. 3) on the bolt body. On the shank of the sleeve is a stud (*c*, Fig. 12) which, moving in a groove (*c*, Figs. 1 and 17) on the interior of the bolt body, also secures together the sleeve and the bolt.

The main spring (Fig. 16) when assembled on the firing pin is supported at one end by the circular band (*a*, Fig. 8; *v*, Figs. 1 and 2) of the striker and at the other by the front face (*d*, Fig. 12) of the sleeve, as shown in Figs. 1 and 2.

The extractor (Fig. 14 and *d*, Fig. 1) is connected by a screw (*o*, Figs. 1 and 3) with the forks of the sleeve (*a*, Figs. 12 and 17); the bevel (*C*, Fig. 14) affording a slight motion to the right, is of use when removing the bolt from the receiver. The hook of the extractor enters a recess (*h*, Fig. 2) in the face of the chamber, into which it is guided by the front of the extractor spring (Fig. 15; *c*, Fig. 14) bearing against the shoulder (*h*, Fig. 1) on the receiver.

From the shape of extractor and its attachment to the sleeve, it also forms a spring, with a tendency to lower the hook, thus insuring the retention of its hold upon the cartridge head secured when the hook enters the recess in the chamber.

The extractor spring (Fig. 15; *c*, Figs. 14 and 18) bears when the bolt is closed against the under side of the shoulder (*h*, Fig. 1) and assists the extractor in retaining the hold upon the cartridge.

The ejector (*v q*, Fig. 1; *e f*, Fig. 2) lies in a mortise in the bottom of the receiver; it is retained there by the pivot pin (*v*, Fig. 1). Being pivoted back of its center the ejector, when the bolt is removed, takes the position shown in Fig. 2; when the bolt is closed (as in Fig. 2), or partly opened, the heel of the ejector enters the groove (*e*, Fig. 3 and Figs. 1 and 18) on the side and bottom of the bolt, permitting the ejector to maintain this, its normal position, but when the bolt is entirely drawn back (as in Fig. 1), as the groove runs over the heel of the ejector the forward part of the bolt (*p*, Fig. 1) strikes and lowers the heel, lift-

ing smartly the toe (*q*, Fig. 1) of the ejector, which throws out the empty shell.

The safety lock (Fig. 13; *d*, Fig. 4) is composed of a thumb piece (*d*) by which it is operated and a spindle (*a*) which, when the bolt is closed and at full cock, can be turned between the front face (*l*, Fig. 11) of the cocking piece and the rear of the body (*a*, Fig. 6) of the bolt, preventing any motion of the firing pin when the trigger is pulled. It also prevents all motion of the bolt and its handle.

The sear spring (*d*, Fig. 2), the trigger, and sear (*t* and *s*, Figs. 1 and 2) are fully shown in the drawing.

The magazine proper (Figs. 19, 20, 21, and 22), formed out of a single piece with the receiver, lies below the receiver, which forms its top, and is an open casing having a flat bottom (*d*, Figs. 20 and 21) merging into a detachable side plate (*e*, Figs. 20 and 21), which forms its curved left side wall. The right side or opening of the magazine is closed by a gate (Fig. 25; *m*, Fig. 19) operated by the thumb piece (*m*, Figs. 19 and 20). The gate is hinged horizontally by the hinge pin (*h*, Figs. 19 and 21) and opens downward (as in Figs. 19 and 20). This pin also retains in a cut (*p*, Fig. 21) below the magazine the lever spring (Fig. 24; *c*, Figs. 20 and 21). The arbor (*a*, Figs. 19 and 23) of the carrier lever engages in a bearing (*a*, Fig. 19) just without the magazine. The action of the mechanism is as follows: The gate being closed, the mainspring bearing upon the right side of the heel (*e*, Figs. 23 and 24) of the carrier lever throws it forward (*b*, Fig. 19) into the magazine, the follower (*d*, Figs. 19 and 23) near its left face. This tends to advance a cartridge from *d*, Fig. 20, around toward *b*, Figs. 20 and 21, causing it to rise from the face up on to the top (*d*, Figs. 19 and 23; *b*, Fig. 21) of the follower, which will then be in the position shown in section *b*, Fig. 21.

Opening the gate (Figs. 19 and 20) the lug (*b*, Fig. 25) comes into bearing upon the surface (*c*, Fig. 23) on the heel of the lever and retracts the lever and follower from the position shown in broken lines *b d*, Fig. 19, to that in full lines in the same figure. A section of the latter position of the carrier is also shown in *n*, Fig. 20.

In Fig. 22 is shown a corresponding section of the magazine with three, of its full number of five, cartridges remaining in it; the follower and carrier (*n*, Fig. 22) are also shown in section. When the magazine is full and the gate closed the pressure of the cartridges forces the carrier and follower back into the gate. When the gate is opened cartridges are introduced into the magazine through the opening (*n*, Figs. 19 and 20).

The magazine is placed in reserve by the cut-off (Fig. 10; *p*, Fig. 19). The thumb piece (*p*, Figs. 10 and 19) turns a spindle (*b*, Fig. 10) whose extension (*a*, Fig. 10) then projects partly over the channel (*b*, Fig. 20; *a*, Fig. 1) from the magazine to the receiver, preventing the passage of cartridges. The spring (*c*, Figs. 9 and 10) retains the cut-off in the position for single or magazine fire in which it may be turned.

Presuming a shot to have been fired, to remove the empty shell, reload, and fire, the mechanism operates as follows:

Beginning to turn the handle (from its lower position, as in the broken lines in Fig. 4) upwards and to the left, the nose of the cocking piece (*m*, Fig. 11) which was buried in the point of the cam on the bolt (*c*, Fig. 3) and which lying in the cut (*l*, Fig. 19) in the tang can not itself turn, is forced back along the cam from *f* toward *m* (Fig. 3), thus withdrawing the point of the striker from the primer and partly compressing the mainspring. Continuing the motion of the handle, the retraction of the cocking piece and compression of the spring continue, and as the handle bears against the curved shoulder of the receiver (*t*, Fig. 19) the entire bolt is slightly carried to the rear, starting the empty shell; just before the handle reaches the vertical, the cock notch (*n*, Figs. 1 and 3) passes the point of the sear, followed immediately by the nose of the cocking piece engaging in the notch (*n*, Fig. 5) in the body of the bolt just beyond the cam (*c m*, Fig. 3). The bolt can then be drawn back, the motion being limited by the locking lug (*k*, Fig. 6) striking the shoulder (*s*, Fig. 19). As the front of the bolt (*p*, Fig. 1) passes over the heel of the ejector, it lifts the toe (*q*, Fig. 1), causing, in connection with the hold of the claw of the extractor, the empty shell to fly out to the front and right.

At the same time, the bolt having passed over the upper cartridge in the magazine, it rises slightly, the upper right-hand portion of its head appearing in front of the bolt.

The mechanism will then be as shown in Fig. 1. Returning the bolt this cartridge is pushed forward, the point of the bullet entering the chamber, and the body of the shell soon after passing into the receiver, after which subsequent movement of the cartridge is directly in the axis of the bore.

The base of the handle reaching the shoulder (*t*, Fig. 19), its subsequent motion is to the right, and as the locking lug engages in its recess (*k*, Fig. 19) and the rear of the guide rib (*z*, Fig. 1; *t*, Figs. 3 and 6) impinges upon the curved surface (*s*, Fig. 19) it moves also slightly to the front, completing the introduction of the cartridge. The sear entering the cocking notch just as the handle reaches the shoulder (*t*, Fig. 19), this turning and slight forward motion of the bolt also further compresses the mainspring. The mechanism will then be as shown in Fig. 2.

It will be observed that the first effect of moving the handle is to withdraw the point of the striker from the primer and to move the locking lug along the face of the locking shoulder, and not until the upward motion of the handle is more than half completed and the bolt moving freely is there any movement to the rear or any pull of the extractor upon the empty shell. To start the shell the camming effect of the base of the handle moving along the surface (*t*, Fig. 19) greatly supplements the force applied by the soldier, and not until the shell is free is there any direct rear pull.

In a similar manner the cam way (*c f m*, Fig. 3) on the bolt body effects, during the rotation of the handle, the first, and then the continued, compression of the mainspring. As it is merely the reversal of these operations which seats the loaded cartridge and completes the compression of the mainspring, the cams again convert the direct push of the handle into a rotation of the latter; both operations are therefore accomplished by a minimum exertion, giving great ease, smoothness, and rapidity to the action.

In case of a misfire it is not necessary to withdraw the bolt to cock the piece, but it may be done either by turning the handle up and then back or by withdrawing the firing-pin directly by means of the thumb-piece (*g*, Figs. 1 and 3).

If the trigger is pulled before the bolt is entirely closed, the nose of the cocking-piece, acting on the cam (*f c*, Fig. 3), will cause the bolt to rotate and become securely locked before the striker can reach and explode the primer.

The magazine can be loaded with single cartridges or from a charging packet, the latter not forming, however, an essential feature of the mechanism. It can also be loaded in any position of the cut-off.

The cut-off can be operated with cartridges in the magazine or with it empty and in any position of the bolt. The cut-off is so placed that it can not be unintentionally operated by the soldier, though its thumb-piece is of such form that the adjustment, for magazine or single fire, can be readily observed by the squad leaders.

The rifle then fulfills in the highest degree the requirements of a single loader and of a magazine arm; easily and quickly loaded for either class of fire, readily convertible from either to the other class, with all its parts simple, strong, and of good size.

The bolt can be readily removed from the receiver and dismounted and assembled without the aid of any tools. No tools are required to dismount and assemble the magazine mechanism.

In conclusion it may be said that to be the most suitable weapon for the infantry soldier the breech and magazine mechanism of the modern rifle should conform to the following conditions—all of them, it may be remarked, fulfilled by the new magazine rifle of the United States:

The arm should be susceptible of use as a single-loader with magazine held in reserve, and should also have the receiver of a form well adapted for such use when the magazine is entirely empty.

The cut off must be in plain view of the squad leaders, and easily operated whether the magazine be full or empty.

The magazine should be readily loaded or replenished with single cartridges and also susceptible of easy loading from auxiliary chargers, but these chargers should not constitute any essential part of the magazine mechanism.

The locking lugs to support the bolt under discharge should be at its forward end, with supplementary supports in the nature of ribs or lugs further to the rear.

The first portion of the motion of unlocking the bolt and starting the empty shell, as well as the final seating of the cartridge and the locking, should be accomplished by a motion of rotation, bringing into play the assistance offered by cams on the bolt, breech casing, or receiver.

While not so essential as the preceding conditions, yet it is desirable that the magazine can be charged whether the bolt is opened or closed, and whether the cut-off is arranged for single or magazine fire.

The bolt is better in one piece, without any separate bolthead, but with the extractor so arranged as not to partake of the bolt's rotation. The compression of the mainspring is best given by cams while the bolt is rotating, and not by the direct push forward of the hand.

It is, of course, essential that the bolt be securely locked before the firing-pin can reach the primer; that the mechanism require but little force to operate; that it be strong and simple, composed of as few parts as possible, and those of good size, and that it can be readily dismounted without the use of special tools and assembled with a minimum number of screws or pins.

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Fig.11.

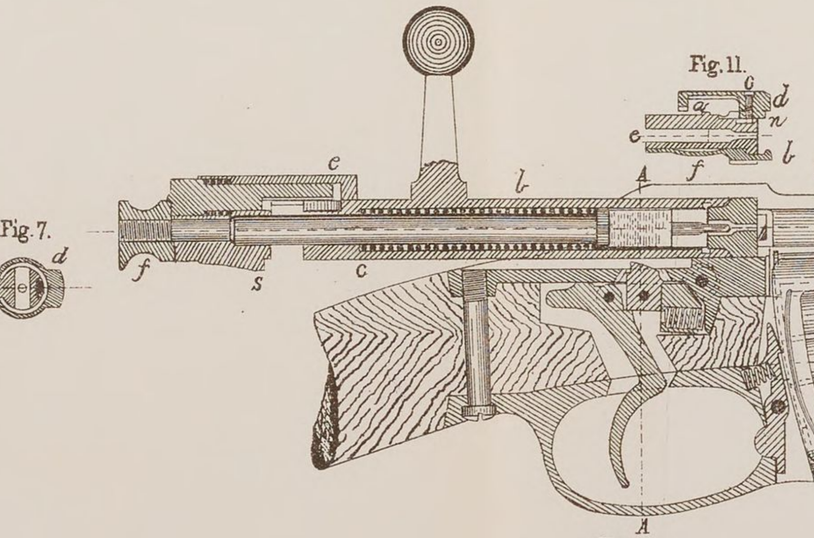
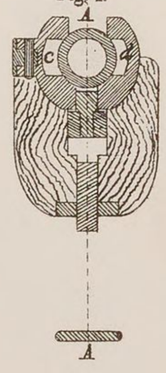


Fig.1.

Fig.4.



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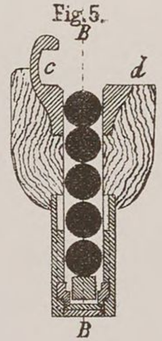

Fig.6.

Fig.7.

Fig.3.

Fig.8.

Fig 13.

Fig.2.

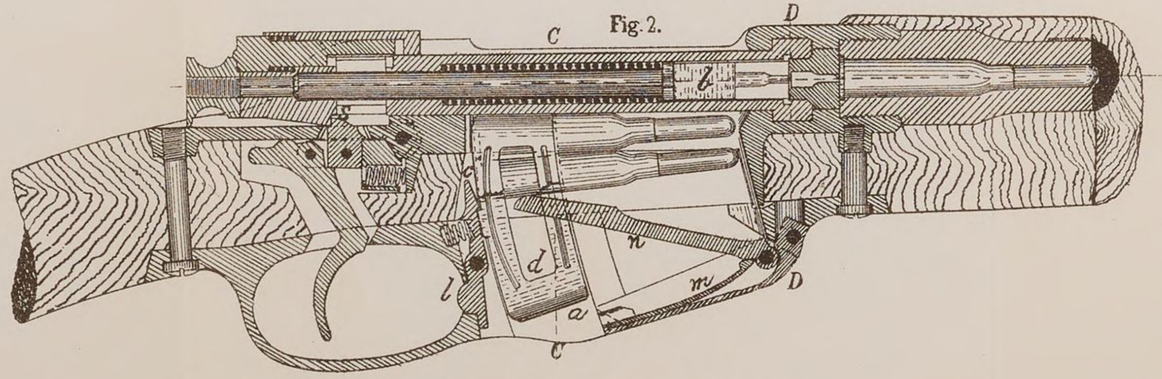

Fig.12.

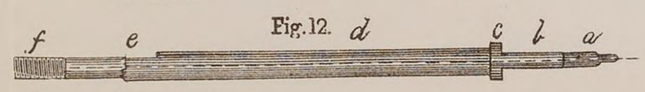

Fig.9.

Fig.10.

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Fig. 3.

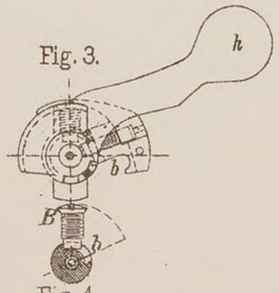


Fig. 4.

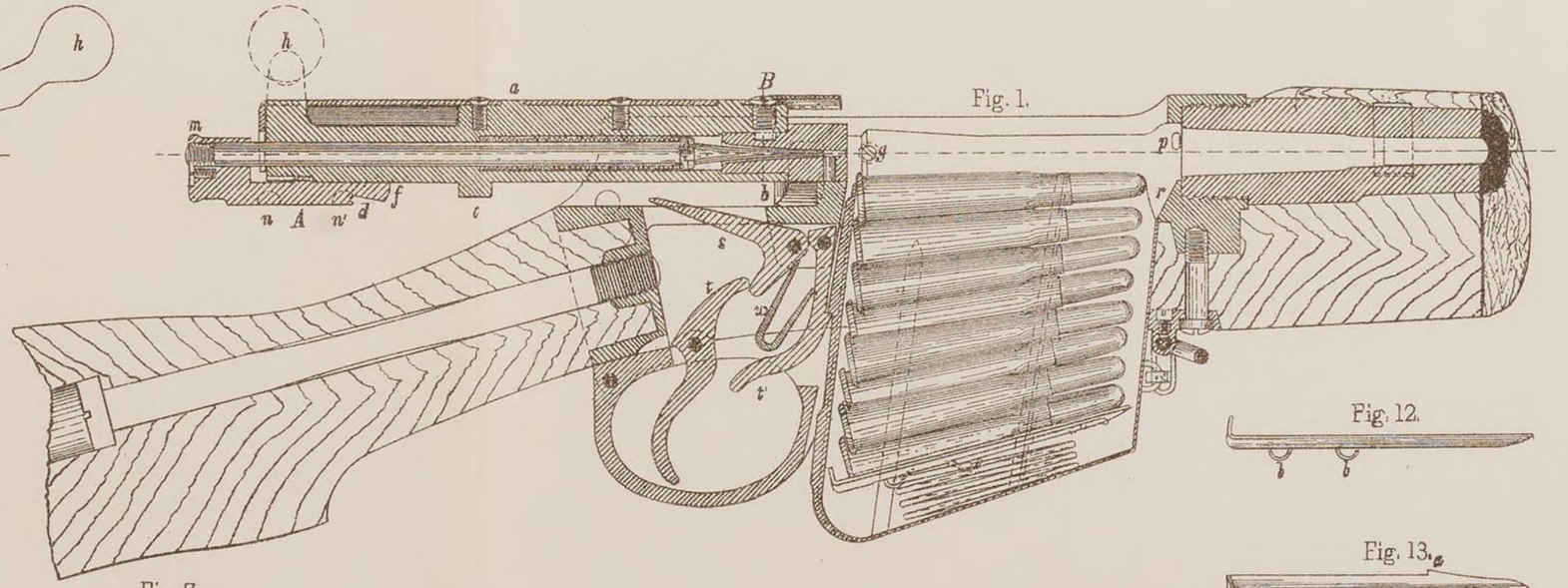


Fig. 1.

Fig. 9.

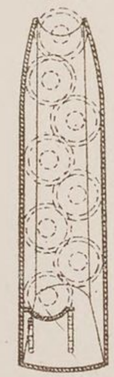
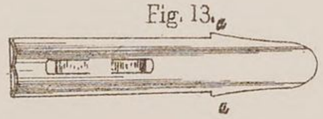


Fig. 12.

Fig. 13.



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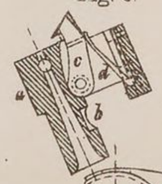

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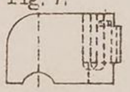

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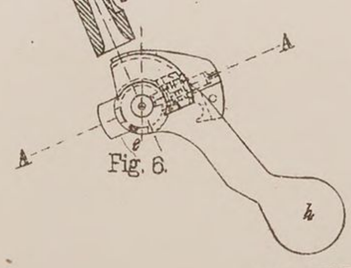
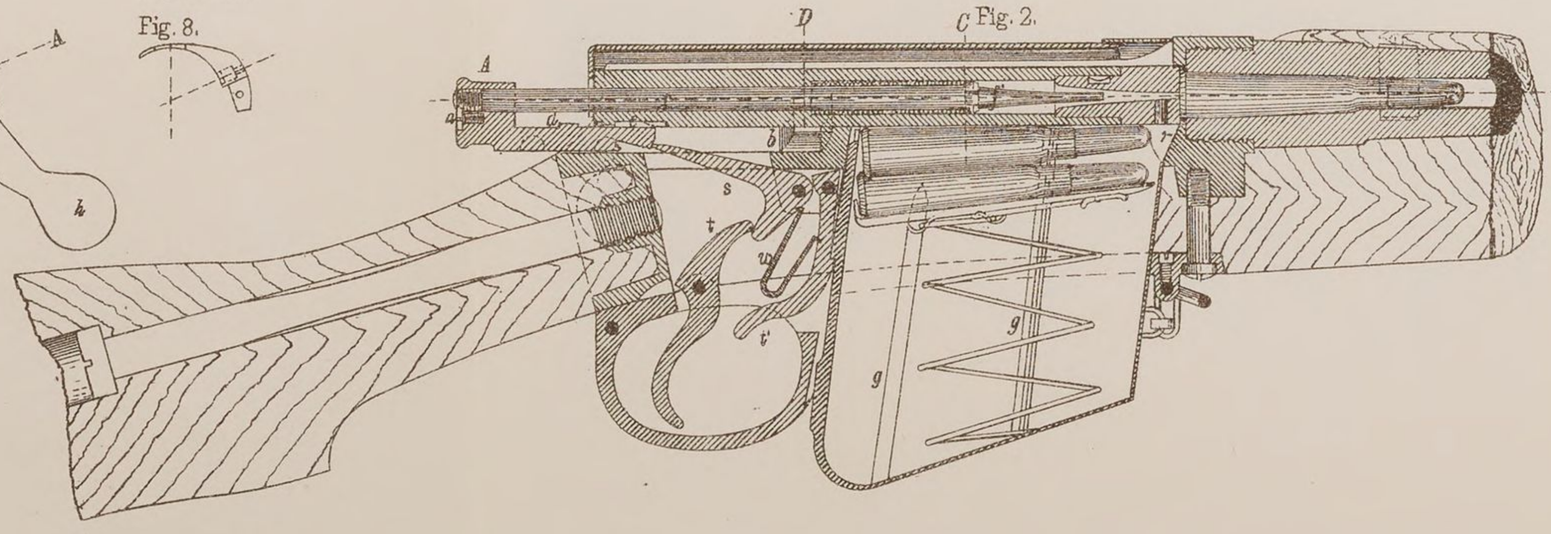


Fig. 6.

Fig. 2.



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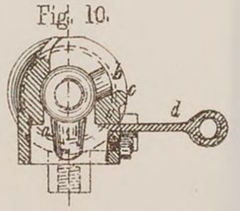

Fig. 11.

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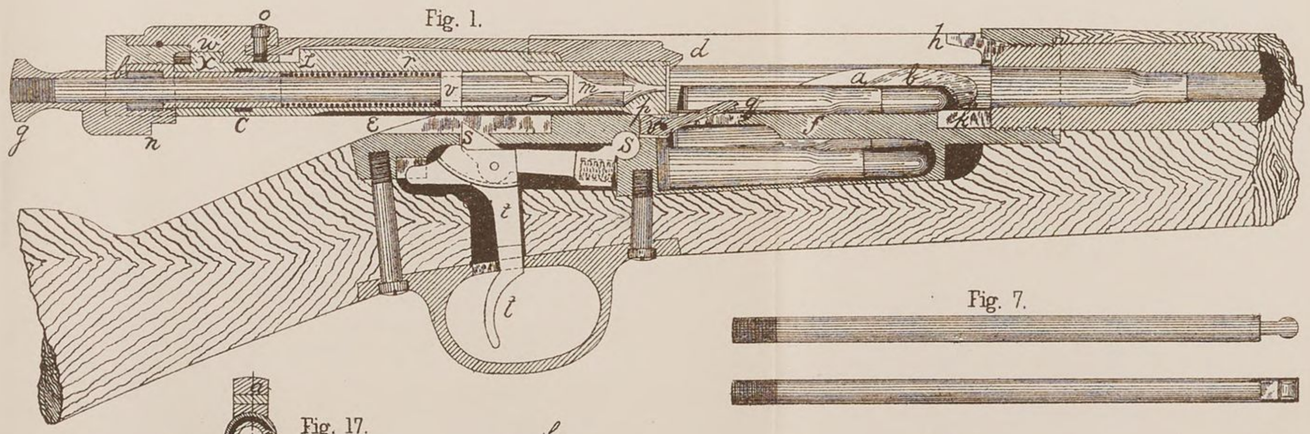
Fig. 1.



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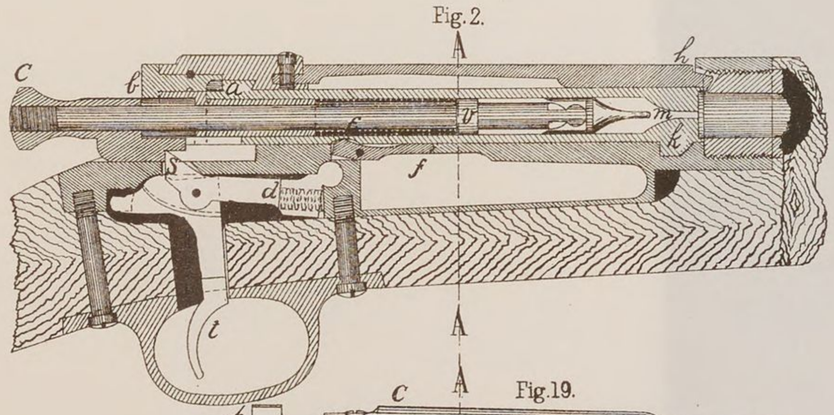


Fig. 7.

Fig. 17.

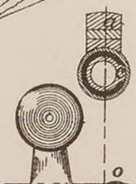
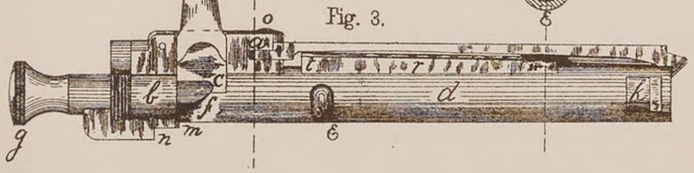


Fig. 18.

Fig. 3.



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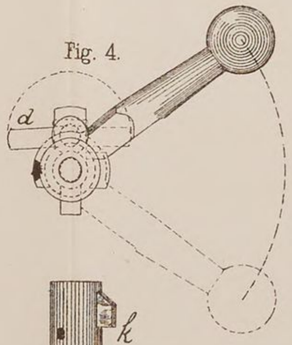

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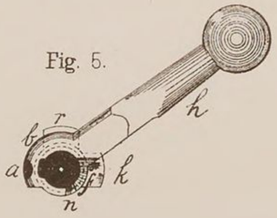

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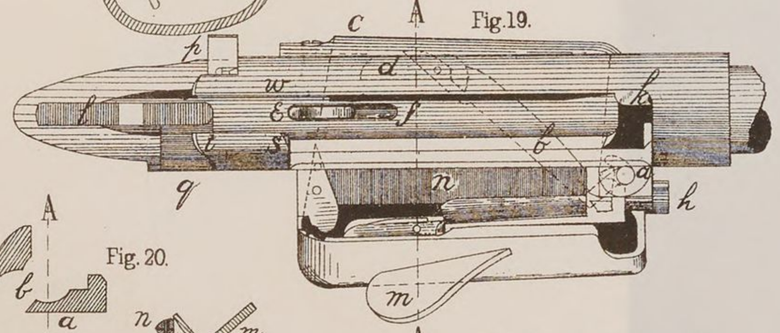

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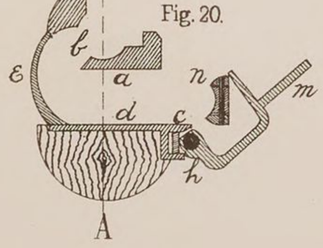
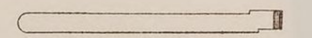


Fig. 23.

Fig. 24.



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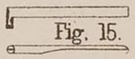

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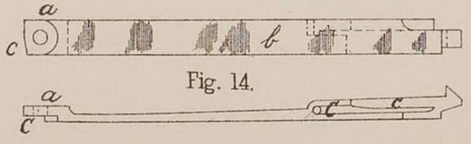

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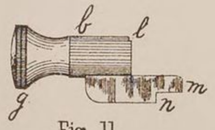

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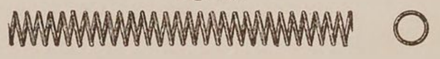

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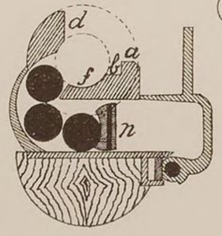

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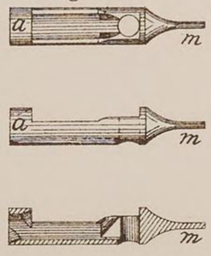

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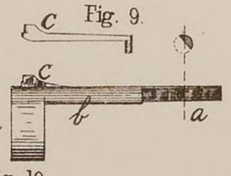

Fig. 10.

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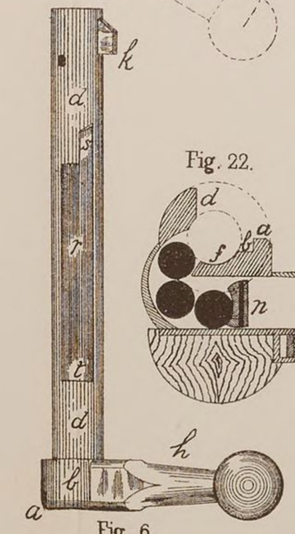

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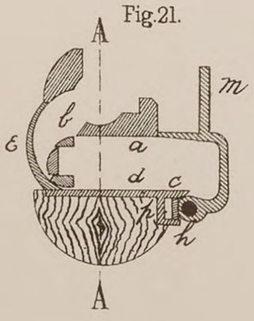

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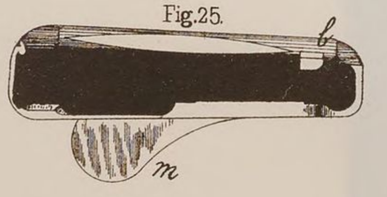

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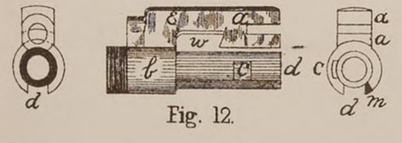

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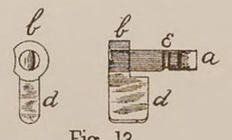

APPENDIX 44.

MODERN GUN CONSTRUCTION AND BREECH MECHANISM. BY CAPT. ROGERS BIRNIE, ORDNANCE DEPARTMENT, U. S. ARMY.

(8 plates.)

It is premised that it will be more profitable in the treatment of this subject to chiefly discuss the principles applicable to the stability of the modern guns rather than to attempt to follow the history of their development or to particularly describe the latest designs. In this country, as elsewhere, the muzzle-loading guns of iron or bronze, and the composite iron and steel guns of an intermediate period, have been, in precept if not wholly in example, supplanted by the steel breech-loading gun of which the present state of development, accompanying the improvements in powders, is principally due to the use of the metal steel and the built-up construction embodying the principles of initial tension. Steel is employed in all parts where strength is important and the building-up process affords the means of about doubling the resistance of the gun over what would be given by a simple tube of the same thickness. We may define a built-up gun as one consisting of a series of concentric simple cylinders or layers, in which the principle of initial tension is secured by the method of assemblage, whether by shrinkage as applied in the use of cylinders of a determinate size or by tension of winding as in a wire-wound gun.

A gun, considered with reference to its endurance under fire and as an instrument of precision, is required to support the strains to which it may be subjected in service without deformation; that is to say, the strength should be sufficient in every important particular to confine the strains within the elastic limit of the material. If the strength be insufficient, weakness will be evidenced from one or more of three important causes corresponding to the direction of the lines of least resistance as opposed to resultants of the principal strains, viz, from enlargement of the bore, due to the tangential or radial strains; from failure athwart the length, either of the body or breech-closure, due to the longitudinal strain; and from bending in the direction of the length, due to the strains which may result in "drooping of the muzzle." As regards the capacity of a gun to sustain a known force of discharge, therefore, the three important points to be separately considered are

that within the elastic limit of the material it shall possess a sufficient tangential resistance, longitudinal resistance, and stiffness or resistance to bending.

The tangential resistance which opposes the bursting effort is relatively of great importance, since it meets the greatest strain in the material and incidentally determines the thickness of the wall and the outline of the gun. It is thus the principal element in economy of structure. Naturally the study of this resistance has received more care and attention than either of the others, and it fortunately admits of a completeness of solution in the built-up construction that fulfills every apparent requirement of a problem wherein a nice adjustment of factors is most desirable.

The longitudinal resistance of the gun body is chiefly opposed by the pressure on the bottom of the bore, which is not difficult to meet, in the usual methods of construction, within dimensions required for the tangential resistance and without sacrifice of that resistance. In some designs of wire-wound guns the plan is adopted of using separate members to support the longitudinal and tangential strains, but ordinarily the purpose is accomplished in a more economical way by using a block carrying cylinder forming a part of the system for tangential resistance, of considerable length for coupling purposes, and of sufficient cross sectional dimensions, as compared with the area of the powder chamber, to reduce the longitudinal strain on the material much below the elastic limit. The tangential and longitudinal resistance may or may not render complementary assistance when the members are combined as last stated, depending upon the mode of construction. With regard to stiffness, for a solidly constructed gun, the case is different, since the tapering form of chase, which conforms to what is required for tangential resistance, conforms also to the shape required to give stiffness of chase; but in a wire-wound gun the coil of wire can evidently afford little assistance to stiffness and this advantage is lost.

In respect to stiffness, the gun constitutes a beam supported by the trunnions at its center of gravity, approximately two-fifths of the length from the breech. The forces operating to bend the chase are its own weight, but especially the bending moment produced by the accelerated velocity of recoil, which moment increases with the angle between the axis of the gun in elevation and the direction of recoil as guided by the slides of the gun carriage. The tendency is always to produce drooping of the muzzle. This effect has long since been observed in short guns—*e. g.*, bronze guns, and notably in the 110-ton English guns of recent date. Although an insignificant factor in the old-style short guns, it has now, in view of the greatly increased length of guns and the present tendency to a still greater increase, become a very important matter and deserves closer investigation than it has apparently yet received, that possibly some exact rules to establish the

requisite factor of safety in different modes of construction may be deduced or determined by experiment.

I.—TANGENTIAL RESISTANCE.

Consider a gun made of homogeneous material, and let θ and ρ represent the elastic limit of the metal under extension and compression, respectively; R_0 and R_1, the interior and exterior radii of the gun; P, the resistance to bursting effort, or the interior pressure per unit of surface that the gun will support without passing the elastic limit of the material.

Understanding by a simple gun one composed of a single tube without initial tension, and by a compound gun one composed either of a simple tube with initial tension or a built-up construction, the value of P for different cases will be given by the formula:

Simple gun. Tangential resistance.	Compound gun. Tangential resistance.	Compound gun. Radial resistance.
$P=\frac{3\,(R_1^2-R_0^2)}{4\,R_1^2+2\,R_0^2}\,\theta.$ (1)	$P=\frac{3\,(R_1^2-R_0^2)}{4\,R_1^2+2\,R_0^2}\,(\rho+\theta).$ (2)	$P=\frac{2\,(R_1^2-R_0^2)}{2\,R_1^2-R_0^2}\,\rho.$ (4)

or for $\theta=\rho$

$$P=\frac{3\,(R_1^2-R_0^2)}{2\,R_1^2+R_0^2}\,\theta. \quad (3)$$

These formulas embody the principle that the resistance is limited by the displacement of the metal at the surface of the bore, where (within limits of practice) the strain is greatest. The simple tube will fail by tangential extension only. The resistance of the compound tube will be proportionate to its initial compression, and failure under pressure will occur either by tangential extension or radial compression, depending upon certain conditions. If we assume the compound gun to be initially compressed to the limit ρ, and assign a series of values to the radii, such as to represent guns with varying thicknesses of wall expressed in terms of the interior diameter or caliber ($2\,R_0$), the curves of resistance which may be thus plotted are as follows: The abscissas represent the thickness (R_1-R_0) of the wall in calibers, and the ordinates the multipliers of θ and ρ in the formulas [using (3) for tangential resistance, compound gun].

The resistance increases with the thickness of wall, but with diminishing increments which become relatively small after a thickness of from 1 to $1\frac{1}{4}$ calibers is reached.

The limiting values of P for an infinite thickness of wall, making $R_1=\infty R_0$, become: Simple gun, $P=0.75\,\theta$. Compound gun tangential resistance, $P=1.5\,\theta$; radial resistance, $P=\rho$.

The elastic resistance of a simple gun can not, then, exceed a pressure on the unit of surface equivalent to three-fourths of the elastic limit of

the material under extension. Eighty-four per cent of the possible strength is attained with a thickness of 1 caliber, and 91 per cent with $1\frac{1}{2}$ calibers. The proportionately greater strength of the relatively thin tube is due to the distribution of the tangential strains throughout the thickness of the wall. In a thick simple tube subjected to interior pressure the circumferential tensions decrease rapidly from the bore outwards, and the outer portions render relatively little assistance. With decrease of thickness the resistance of the outer fibers is more fully developed and the same conditions of resistance are approached as by the application of initial tension in compound cylinders.

The two upper curves, Fig. 1, represent the resistance of a compound gun under the conditions that the bore is initially compressed to the full elastic limit and that $\rho=\theta$. These conditions are taken for purposes of illustration and because it is usual in steel constructions to consider $\theta=\rho$. It is not practicable to derive the benefit of full initial tension from a less thickness than 0.6473 caliber; hence these curves are broken (imaginary) within that thickness. To such failing cases the general formula (2) would be applicable in introducing determined values for ρ and θ considered as working limits, the value of P being then equal to the product of the sum $(\rho+\theta)$ into the multipliers for the curve of tangential resistance, simple gun.

Considering the full curves as shown, the tangential resistance of the compound gun is just double that of the simple gun, and the limit of elastic strength is equivalent to 1.5 times the elastic limit of the metal under extension. The curve of radial resistance lies below the other beyond the point which marks a thickness of about 0.29 caliber, and should therefore for a greater thickness of wall be taken as the true curve of resistance—that is to say, the *elastic* resistance of a compound gun is theoretically limited to a pressure on the unit of surface equivalent to the elastic limit of the material under compression.

Clavarino[1] has attempted to prove that, "if there were nothing to apprehend for the safety of the construction when the internal pressure ceases to act," the resistance might be increased by hooping to three times this amount. But in order to reach this conclusion he assumes that the metal in place in the gun is subjected to cubic compression, and hence offers a much greater elastic resistance than is indicated by the tests of free specimens. To this end his formulas are made to exemplify the case of a tube closed at both ends, with the interior and exterior pressure acting upon both faces of the ends as well as radially. This case does not exist in fact, and although some measure of the force supposed to act upon the outside end faces may be supplied by the longitudinal pressure on the tube derived from the friction of shrink-

[1]Article published in "Giornale d'Artiglieria e Genio," Rome, 1879, translated in "Notes on the Construction of Ordnance No. 7," Ordnance Office, U. S. Army, Washington, 1882.

age, yet his assumption must be considered as overdrawn.[1] While admitting that there will be in practice a gain of resistance in the direction pointed out by Clavarino, still it will be best not to depart from our present formulas in *designing* a gun, because they are more rational, and it is best to err, if at all in this matter, on the side of safety.

The gain of resistance referred to may be best conserved by constructing a gun (with weight, length, etc., approximately fixed by requirements of service) with reference to the best conditions for tangential resistance, even though by so doing there may be an apparent slight sacrifice of radial resistance as indicated by a rigorous application of the formulas.

Hence in computing the shrinkages for a built-up gun it is the general practice to consider the value obtained for the tangential rather than the radial resistance as giving a more favorable arrangement of the system as a whole. The radial resistance can be finally computed when all other conditions are fixed, and if it is found to be less than the tangential, then it may be put down as the *elastic* resistance of the gun. In practice, however, this last operation is frequently omitted and the tangential value alone is given. This may be defended upon the ground, already discussed, that the strength as estimated by the formula for radial resistance is really underrated, and hence the (greater) tangential value may be taken as more nearly the true one. In view of these considerations general discussion of the bursting effort in a compound gun may be, as it is in a simple gun, confined to the tangential strains.

INITIAL TENSION.

The principle of initial tension is embodied in the law of *tangential* strains, and the manner in which it acts to increase the resistance to interior pressure is the same in a single tube as in a built-up gun. The difference is principally in the mode of application, being in the one case concerned with the cylindrical laminæ of the single cylinder and in the other with the separate simple cylinders of the built-up construction. A maximum resistance corresponds to such an arrangement of the system that when the interior pressure, which determines this resistance, is applied all the members will be simultaneously strained tangentially to their elastic limit, and it is the object of initial tension to secure this arrangement, as nearly as may be practicable, in the different plans of construction.

In a single tube the curve of initial tension is continuous, and the principle may be illustrated as follo vs: In Fig. 2 is shown the case of a cylinder 0.6473 caliber in thickness; hence $R_1 = 2.2946\ R_o$ and, formula (3), $P = 1.11\ \theta$.

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[1] The *changes of length* due to shrinkage as derived from Clavarino's formulas are the reverse of those determined by experiment. See page 21, "Notes on the Construction of Ordnance, Nos. 32 and 38."

Given a metal with equal elastic resistance under compression and extension ($\rho = \theta$), a cylinder of this dimension illustrates, in accordance with the law of tangential strains, the fullest extent to which the principle of initial tension can be utilized. Its remarkable properties may be otherwise stated, that it fixes for a required resistance the minimum elastic limit of metal that can be fully utilized to procure that resistance. Again, having a metal of given strength, it fixes the maximum thickness that will fully utilize the elastic limit, or, otherwise stated, the thickness up to which the resistance of a cylinder may be made, substantially, directly proportional to its thickness, and beyond which the increase of resistance will be disproportionate to the thickness in a rapidly diminishing ratio; hence it may be called the cylinder of maximum utility.

For example, let it be required to construct a cylinder having a bore of 8 inches which will support an interior pressure of 40,950 pounds per square inch. Then, from what precedes,

$$2R_0=8 \therefore R_0=4. \quad R_1=2.2946R_0 \therefore R_1=9.1784 \text{ and } 2R_1=18.3568.$$

Also, the required elastic strength of metal will not be more than

$$\rho=\theta=P \div 1.11=45000.$$

The case taken exemplifies the particular one wherein, the bore being initially compressed to the elastic limit, on the application of the interior pressure, the tangential strains increase until they are uniform throughout the thickness of the wall and at the same moment equal to the elastic limit of the metal. These conditions evidently give the maximum utilization of material, since every fiber of metal is exerting its full elastic resistance. The curve of initial tension extends from 45000 compression at the surface of the bore to 21600 extension at the exterior surface, crossing the axis of radii at the neutral point *a*, where $r=1.487 \times R_0=5.95$ inches. The areas of compression *a b c* and of extension *a d e* represent the work of the two forces in equilibrium, system at rest. The horizontal line indicated by $\theta=45000$ represents the changed position of the curve of initial tension, or the state of extension of the wall due to the application of the maximum interior pressure, and rectangle *b d f g* is the strain area system in action. The curve of pressure descends from 49950 at the surface of the bore to zero at the exterior surface.[1]

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[1] The thickness of wall in terms of caliber, giving maximum "utility," and the curves of strains and pressure are deduced as follows:

Starting with the conditions for maximum resistance, namely, that when the limit of interior pressure is reached the whole thickness of wall shall be uniformly strained to the elastic limit of metal, and that on removal of the interior pressure the tangential compression of bore shall be equal to the elastic limit of metal, we have—

$$P=\frac{3\,(R_1^2-R_0^2)}{4R_1^2+2\,R_0^2}(\rho+\theta). \quad (2) \qquad \theta=\frac{2}{3}\frac{P}{\left(\frac{R_1}{R_0}\right)^{\frac{2}{3}}-1}=aP.$$

No other thickness of wall will fulfill these special conditions, which explains the reason for the imaginary form of the curves for the resistance of a compound gun in Fig. 1, as already referred to. Observing that the curve of initial tension is convex upwards, if the wall were thicker, the curve of extensions would pass the horizontal stage and become convex downwards; when, under the action of P, the limit θ

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the latter of which shows the relation which must subsist between P and θ such that the extension shall be uniform through the wall.

Equating the values of P from (1) and (2), substituting $b=\frac{R_1}{R_0}$

and reducing, we obtain

$$b^{\frac{8}{3}}-\frac{30+\rho}{20}b^2+0.5\,b^{\frac{2}{3}}+\frac{\rho}{20}=0$$

from which, by assigning values to ρ and θ, we may find the corresponding value of b pertaining to the cylinder of least thickness that will support P. For $\rho=\theta$, we find $b=2.2946$. Hence $R_1=2.2946R_0$. Then R_0 being taken as unity,

$$\text{Thickness in caliber}=\frac{R_1-R_0}{2R_0}=0.6473.$$

If $\rho>\theta$ the value of b would be increased. If $\rho<\theta$, or be so taken as a definite working limit, the value of b would be decreased.

Curves of initial tension and pressure.—P=49950, and by hypothesis $\theta=45000$, uniform through the wall with P acting. Supposing P removed, the extensions will relax and the right line ($\theta=45000$) will assume the position indicated "initial tension curve." The change of extension at any radius, r, for the change in pressure, P, is given by the formula—

$$\theta=-\left(\frac{3R_0^2}{3(R_1^2-R_0^2)}+\frac{4R_1^2R_0^2}{3(R_1^2-R_0^2)}\frac{1}{r^2}\right)P.$$

Substituting successively $r=R_0$, 1.2, 2.0 and R_1, and laying off the resulting values of θ downward from the right line stated, we get the corresponding points of the initial tension curve having the values $\rho=45{,}000$, $\rho=19864$, $\theta=16700$, and $\theta=21600$. The neutral point a, where this curve cuts the axis of radii, is given by the equation,

$$r^2=\frac{2R_1^2R_0^2\left[\left(\frac{R_1}{R_0}\right)^{2/3}-1\right]}{R_1^2-R_0^2\left(\frac{R_1}{R_0}\right)^{2/3}}$$

whence by solution, $r=1.487$.

The intermediate point on the pressure curve designated by the value 22650 is obtained from the equation

$$p=\tfrac{3}{2}\theta\left[\left(\frac{R_1}{r}\right)^{2/3}-1\right]$$

in substituting $\theta=45000$ and $r=1.487$. The pressure at the exterior surface is zero, the atmospheric pressure being neglected.

The formulæ used in this connection are taken from Appendix B of a previous paper, entitled "Gun Making," and published in the April, 1891, issue of the Journal of the Military Service Institution, Governors Island, New York.

was reached at the surface of the bore, whilst toward the exterior the extensions would be less than θ. The value of P would, of course, derive a certain increase from the increase of thickness. If ρ were greater than θ, initially, the proportion would be restored, and for this condition a cylinder of greater thickness than 0.6473 caliber could be brought to the condition of uniform extension.

On the other hand, if the wall were thinner than 0.6473 caliber, with the full initial compression $\rho=\theta$ given, the initial extensions at the exterior would be proportionately greater than in the example taken. The curve of extensions would remain convex upwards under the action of P, and the limit of resistance would be reached when the extensions at the exterior became equal to θ, whilst toward the interior they would be less than θ. But if ρ be taken less than θ, initially, the proportions would be restored, and, as this is an entirely supposable case, it follows that the condition of uniform extension under the action of an interior pressure can be secured in a cylinder of less thickness than 0.6473 caliber, the values of ρ decreasing with the thickness. In any case, however, the value of P is directly proportional to the sum $\rho+\theta$, formula (2). And the series of values for P obtained in this way for varying thicknesses below 0.6473 caliber would also be, substantially, directly proportional to the thickness of cylinder for a constant value of θ.

The only example of solid tubes at present manufactured with initial tension for use in gun construction in this country are the cast-iron bodies for the steel-hooped 12-inch mortars. These bodies are cast hollow on the Rodman plan, and initial tension is produced by cooling with water through a core placed in the casting mold. The actual initial tension is determined for each casting by cutting thin rings of metal from near the bore and outer surface. Diameters of the rings are measured before and after the separation to determine the strains, whether positive or negative, by which the ring was held in restraint. Calling the original diameter D, and its measured expansion or contraction, on removal, d, we have—

$$\frac{D}{+d}E=\rho \quad \frac{D}{-d}E=\theta$$

(E being the modulus of elasticity) which express the tangential strains existing in the castings at the place from which the ring was taken. The value of ρ thus determined for the ring next the bore is used in connection with the general formula (2) in estimating the resistance of the mortar. The observed tangential extension in the rings taken from near the exterior of these castings is less than it should be owing to the cooling, which can not be prevented at the exterior surface, and the process produces an irregular though beneficial state of initial tension. To complete these rifled mortars the cast-iron body is strengthened by shrinking on a double row of steel hoops, which extend from the breech to a distance forward of the trunnion ring.

II.—MODES OF CONSTRUCTION.

In presence of the necessity for employing initial tension in modern high-powered steel guns many good reasons are adduced for discarding the solid in favor of the built-up construction. The difficulties with the solid construction are almost wholly mechanical, but we are none the less far short of being in a position to overcome them; its adoption, although desirable, must wait until the larger masses of steel can be made and treated so as to insure uniformity and combined physical qualities of material equal to those secured in the smaller forgings, and, further, until a means is devised for producing a desirable state of initial tension with certainty and regularity, whilst avoiding the local and irregular strains of great intensity which are apt to occur and make the result rather more detrimental than otherwise. On the other hand, the smaller parts used in the built-up construction do admit of excellence in the material, and the method affords the means of securing the greatest strength of structure compatible with the quality and weight of metal contained. Excepting for small arms and some special classes of light cannon to which the principle of the simple tube is applicable, this method of construction is now universally employed. Two schools are represented which differ chiefly in the practical application of the principles involved.

The forged steel gun made throughout of cylinders of a determinate size has for advocates those who will not depart from a fundamental principle that none of the strains to which the structure is subjected shall exceed the elastic limit of the material; who also seek to reduce the number of parts and solidify the structure in measure as the art of steel-forging manufacture progrésses, and depend likewise upon improvements made in the physical qualities of the forgings to increase the resistance and power of the gun within given limits of weight and dimensions. It is noticeable in the history of this type of gun that the length of the cylinders surrounding the tube have been steadily increased from its first conception; and its legitimate finality is a gun made, if not of one simple cylinder in each layer at least so nearly so as to meet the requirements for longitudinal stiffness and minimize the cost of production in pace with increased length of bore.

The wire-wound gun is advocated for the high elastic properties of metal attained by still further comminution of material in manufacture, and it is sought by various combinations of such small parts to utilize their intrinsic properties in resisting the strains in the gun and thus enable the use of correspondingly high powder pressures. When this principle is carried to its legitimate conclusion it naturally brings about a multiplication of parts and complication of structure that enhance the difficulties if not the cost of manufacture. On this ground it might not be objected to, provided there be a commensurate gain in power of gun. There is a limit, however, to the division of parts which

may be made in a gun whilst preserving its integrity, and the difficulty arises in applying the small parts with their high elastic properties in every important part of the structure. Hence we find that in most designs of wire guns this principle is sacrificed in part and the core upon which the wire is wound, or an integral part of it, is composed of a tube forging substantially the same as is used in the forged gun. Based upon general principles the elastic tangential strength of a wire gun so constructed can not exceed that of the forged gun. The point here involved has been stated by Capt. Crozier as follows:

> But the difficulties of attaining, even theoretically, the high tangential resistance claimed by most of its advocates for the wire construction is not so generally understood. Misapprehension upon this point has been fostered by the assumption of unattained and unattainable values for the physical constants in cast iron and steel (I do not refer to the elastic limit of the steel wire, that has been generally understated), and by their declining to be governed by the rule so strictly observed by the designers of built-up guns that no part of the structure shall be strained beyond the elastic limit of its material either at rest or under fire.
>
> If the tube, which necessarily forms the core in all systems of wire construction, is to be subjected to this law, then a wire gun can, in general, be made no stronger than a built-up one of the same thickness. For the formula

$$P_0 = \frac{3(R^2_1 - R^2_0)}{4R^2_1 + 2R^2_0}(\rho + \theta)$$

> giving, as it does, the admissible powder pressure under the supposition that the metal at the surface of the bore undergoes a range of dilation from the elastic limit of tangential compression at rest to that of tangential extension under fire applies equally to built-up and to wire guns.
>
> We must disabuse our minds of the error likely to find hasty lodgment there, that the wire affords a more rigid support to the tube than surrounding parts of forged steel do. The rigidity of this support depends upon the modulus of elasticity of the supporting material, and that for steel wire is no greater than for forged steel.

In effect those designers of wire guns who adhere to the same form of tube as used in the forged gun, but aim for a higher tangential resistance, do avowedly ignore the rule which confines the initial compression of bore to the elastic limit of the material and introduce a greater state of compression, which according to the formulæ of construction will cause the metal at the surface of the bore to be tangentially compressed beyond its elastic limit. What effect this may have upon the life of the gun can only be determined by endurance tests, which should be made with pressures corresponding to the high resistance claimed. It may be conceived, however, that such a condition would be unfavorable in metal subjected to repeated strains, and may facilitate erosion. Drawings of the Woodbridge and the Crozier 10-inch wire-wound guns which embody this heavy compression of tube are shown on Plate IV. These guns are now undergoing test.

On the same plate is shown the Brown segmental 5-inch wire-wound gun, which illustrates in its construction a method of utilizing more fully the high elastic properties derived from the manufacture of material in small masses, and obtaining a relatively high tangential resist-

ance, without exceeding in any respect the elastic limit of the material. The short lining tube is made of crucible steel having an elastic limit of metal equal to about 112,000 pounds per square inch, and the tube being shrunk in place (by hydraulic pressure) gives place for the requisite movement of bore within its limits of elastic displacement. The segmental cylinder, which forms the principal part of the core and the surface of the bore forward of the liner, is composed of bars of similar quality of steel. It is subjected to an initial compression by the wire envelope which does not exceed the elastic limit of the metal and is estimated to be more than sufficient to prevent the joints from opening under a powder pressure of 52,000 pounds per square inch. In effect the maximum resistance of the gun or the pressure which will reduce the compression between the bars at the surface of the bore to zero—thus falling just short of opening the joints—is, as estimated by Lieut. Whistler, 63,500 pounds per square inch.

It is to be observed that this maximum resistance is given for an estimated compression of 103,000 pounds per square inch between the bars and that this state of compression is never (can not be) relieved, and therefore the elastic strength of the metal is utilized in only one direction instead of through the double range, as would be admissible if the core instead of being made of segments were a solid cylinder. The construction is uneconomical in the sense of utilizing the high elastic properties of metal present; that is to say, it has been necessary in making the gun of so many parts to use metal of far higher physical qualities than would be required to secure the same tangential resistance in another and less complicated way. Thus, the wall of gun over the powder chamber has a thickness of about 1.17 calibers. If made with a solid tube the tangential resistance, from formula (2), would be represented by

$$P = 0.653\ (\rho + \theta)$$

If $\theta = \rho = 103{,}000$ (as given for the segments) we should have P = 134,500. It is not reasonable to suppose that simple cylinders of large dimensions can be made with such high elastic properties, but if P be fixed at the given value, 63,500 pounds, we find

$$(\rho + \theta) = 97{,}220 :: \rho = \theta = 48{,}610$$

showing that if a gun of the same caliber and dimensions as this were constructed of simple cylinders shrunk together as in the forged cylinder construction, an elastic limit of about 50,000 pounds per square inch would be required in the metal to give about the same tangential resistance. And if a metal having an elastic limit of 66,000 pounds were provided this construction would give a *radial* resistance of 63,500 pounds, and meet every requirement of principle.

Another matter to be considered in connection with the question of wire wound versus the forged cylinder construction is the erosion of bore as limiting the useful powder pressure. The endurance tests of the built-up forged guns have shown that the wear and power of the

gun are limited by erosion and that the resistance of these guns is more than sufficient at present to withstand the pressures or other causes which determine this erosion. I conclude that on the whole there is little to be gained in attempting to make wire guns to be professedly stronger tangentially than the forged gun. And if equal strength only is aimed at, then the forged gun has the advantage of being inherently the more solid and stiffer construction.

III.—CLASSES OF GUNS.

Guns may be understood to embrace all kinds of fire-arms. For military purposes, exclusive of small arms, they are classified, generally, as machine guns, rapid-fire guns, and mountain, field, siege, and heavy cannon. The classes of mountain cannon are further divided into guns (specifically so called) and howitzers; and of field, siege, and heavy cannon, into guns, howitzers, and mortars. Each of these is designed to meet certain conditions and requirements of service, the primary object being to secure the best ballistic effect for the service intended, given a powder of known force and the dimensions or weights of material which should not be exceeded. The powder pressures deduced for the ballistic results will be in turn limited by the strength of the gun which can be constructed under such limitations, and this will depend upon the qualities of the material and the mode of construction.

Before passing to a further account of the methods of construction of our present service guns of field and heavier calibers, I may refer to the resistance of the small-arm gun barrel, which is a simple tube of forged (or rolled) steel. The barrels of machine guns are of the same description, as are also those of the smaller calibers of rapid-fire guns, whilst for 3-pounders and upwards the rapid-fire guns, although of relatively greater length of bore, are built up in a similar manner to ordinary guns of like calibers.

Small-arm barrel.—Enlargement of the bore, with loss of velocity, will appear after repeated firings if the elastic resistance of the barrel is insufficient to withstand the powder pressure. Higher powder pressures are called for with the diminution of caliber now being introduced, and higher qualities of metal are required for the barrels than were formerly required for the .45 caliber weapon. In some experiments recently made at the Springfield Armory in testing samples of .30 caliber rifle barrels a loss of velocity from 80 to 100 foot-seconds in 1,000 rounds was observed. Two barrels of the same quality fired at the Frankford Arsenal showed no appreciable loss of velocity after 1,000 rounds, but in one of them a slight enlargement was observed near the seat of the bullet. These barrels were evidently below the limit of resistance required. The data to be observed in the experiments were: Elastic limit of metal, 45,000 pounds per square inch; powder pressure, as determined by crusher gauge, about 40,000 pounds per square inch,

and thickness of barrel over seat of projectile 1.13 calibers. The formula for elastic resistance of a simple tube gives in this case

$$P=0.65\times 45{,}000=29{,}250 \text{ pounds per square inch.}$$

or about 10,000 pounds below the measured pressure. Conversely, to withstand 40,000 pounds pressure, the elastic limit of metal should be $40{,}000\div 0.65=61{,}500$. A steel containing 3.5 per cent of nickel and having an elastic limit of 85,000 pounds per square inch with 15 per cent ultimate elongation has been more recently introduced at the Springfield Armory for experiment. As far as worked it appears also to possess other requisites for gun-barrel steel in being free from foreign matter and hard spots, does not injure the tools, and produces a finished barrel free from seams and imperfections.

The rolling of gun barrels in manufacture, as frequently practiced, is considered to improve the qualities of the steel. Mr. Rigby, superintendent of the Enfield Factory (England), in a lecture before the Institute of Civil Engineers. November 29, 1892, quotes Messrs. Marcotty (Berlin) as authority for the following results of their rolling process in making gun barrels:

	Elastic limit.	Breaking stress.	Elongation.	Contraction of area.
	Tons.	*Tons.*	*Per cent.*	*Per cent.*
Steel before compression	23.6	44	19.0	39.
Steel after compression	37.0	51	11.5	39

Mr. Rigby adds that he had found at Enfield, by taking specimens from the bars before and after rolling, a considerable increase in the stiffness and strength of certain qualities of steel, though not to the extent claimed by Messrs. Marcotty.

This source of improvement may account for results in some cases where barrels made of steel having lower qualities than our formula indicates to be necessary do withstand a given pressure; but it would appear best to count upon such improvement merely as an increased factor of safety, and at most not go below the indications of the formula in selecting the original qualities of metal for barrels.

SERVICE GUNS OF THE UNITED STATES.

The guns of the land and naval services, of which the dimensions, etc., for the latest models of 3 inches caliber and upwards, are given in Table I and II, are of the built-up, forged steel constructions, with slotted screw breech closure. Exceptions as to mode of construction occur in the 3.6-inch and 7-inch rifled mortars of the land service, which by reason of the low powder pressures employed are composed of a single tube of forged steel, and in one pattern of the 12-inch rifled mortar (seacoast) which comprises a cast-iron body, reinforced by two layers of forged steel hoops. In Table I (land service) the figures are given for comparing the tangential resistance of the section of the powder

chamber with the actual powder pressures. The proportion of the available tangential resistance called into play varies from about 70 per cent in the seacoast guns to 90 per cent in the field and siege guns. The *radial* resistance is likewise in all cases in excess of the actual pressures; its value in the heavy seacoast guns is nearly 40,000 pounds. This is considered a safe pressure for repeated firings, one which will not cause the elastic limit of the material to be exceeded in any respect, and is from 2,000 to 3,000 pounds in excess of the powder pressures. It will be remembered, of course, that these figures relate to the *elastic* strength of the guns and not to actual rupture; they in no sense involve the work that would have to be done by the powder pressure in stretching the very ductile metal through the range between its elastic limit and the limit of rupture.

TABLE I.—*Breech-loading ordnance, U. S. Land Service.*

[Guns, howitzers, and mortars of 3 inches caliber and upwards.]

	Hotchkiss mountain gun, steel.	Field artillery, steel.			Siege artillery, steel.		
		Light gun, model 1890.	Heavy gun, model 1891.	Mortar, model 1890.	Gun, model 1890.	Howitzer, model 1890.	Mortar, model 1892.
Caliber .....inches..	3	3.2	3.6	3.6	5	7	7
Weight:							
Pounds.....	218	805	1,181	244	3,660	3,710	1.715
Tons	.....	.....	.....	.....	.....	.....	.....
Total length .....feet..	3.76	7.31	7.79	2.05	12.15	8.475	4.86
Length of bore .....calibers..	13.48	25.20	23.50	5.19	27	12.67	7
Diameter over powder chamber .....inches..	6.7	9.00	9.80	7.50	15.0	16.70	13.80
Diameter of powder chamber, inches.....	{3.15 / 3.21}	3.60	3.30	3.80	5.7	7.20	7.25
Thickness over powder chamber..... calibers..	0.55	0.75	0.76	0.48	0.82	0.66	0.45
Number of cylinders comprised in the thickness.....	1	2	2	1	2	2	1
Maximum tangential resistance....pounds per sq. in..	23,850	38,080	39,160	22,050	37,520	35,120	22,000
Rifling:							
Number of grooves.....	24	24	26	20	30	42	28
Width of grooves.inches.	0.276	0.3	0.3162	0.4454	0.3736	0.3736	0.6354
Depth of grooves.inches.	0.026	0.04	0.04	0.045	0.05	0.05	0.055
Width of lands...inches..	0.117	0.1188	0.1188	0.12	0.15	0.15	0.15
Twist .....calibers..	{1 in 25.59 / uniform	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 15
Total capacity of bore, cubic inches.....	292	689.3	894.5	200.2	2,824.5	3,520.1	2,917
Capacity of powder chamber, cubic inches	27.12	108.9	149.2	33.2	395.6	315.7	182.8
Length of powder chamber, inches.....	3.72	10.7	12.275	2.835	15.15	7.465	6.67
Travel of projectile in bore, calibers	12.243	21.81	20.08	4.47	23.96	11.61	6.40
Powder charge:							
Kind	(a)	(b)	(b)	(b)	(b)	(a)	(c)
Weight.....pounds..	0.875	3.5	4.1875	15 ozs.	12.5	10	5.5
Density of loading	0.9	0.89	0.777	0.833	0.875	0.877	0.833
Projectile:							
Weight.....pounds..	12	13.5	20	20	45	105	125
Ratio to weight of piece..	1 to 19	1 to 60	1 to 59	1 to 12	1 to 81	1 to 35	1 to 13
Pressure in powder chamber, pounds per square inch	14,560	35,000	35,000	16,000	35,840	28,224	18,000
Muzzle velocity..feet-second.	870	1,685	1,550	650	1,830	1,085	690
Muzzle energy ....foot-tons..	63	266	333	59	1,045	857	412
Penetration of steel:							
Muzzle .....inches..	1.4	3.8	3.9	1.1	6.2	3.8	2.2
3,500 yards .....inches..	.....	.....	.....	.....	2.5	2.4	.....

a I. K. granular. *b* U. R. sphero-hexagonal, *c* I. B. sphero-hexagonal.

TABLE I.—*Breech-loading ordnance, U. S. Land Service*—Continued.

	Seacoast guns, steel.					Seacoast mortars.	
	Model 1888, M.	Model 1888, M.	Model 1888, M.	Model 1892.	Proposed.	Cast iron, steel-hooped.	Steel.
Caliber ..... inches..	8	10	12	12	16	12	12
Weight:							
Pounds	32,372 / 32,480	67,200	116,480	128,719	280,000	31,920	29,120
Tons	14.5	30	52	57.5	125	14.25	13
Total length ..... feet..	23.21	30.60	36.66	40.0	49.67	10.75	11.76
Length of bore ..... calibers..	32	34	34	37.83	35	9	10
Diameter over powder chamber ..... inches..	30	38.5	46.2	46.4	62	41.75	38
Diameter of powder chamber, inches	9.5	11.8	14.2	14.5	18.8	12.4	12.5
Thickness over powder chamber ..... calibers..	1.08	1.13	1,125	1.10	1.148	1.18	1.02
Number of cylinders comprised in the thickness	3	4	4	4	4	3	3
Maximum tangential resistance .... pounds per sq. in..	51,980	53,090	53,000	52,640	53,000	29,490	50,200
Rifling:							
Number of grooves	48	60	72	72.0	96	68	72
Width of grooves .inches.	0.3736	0.3736	0.3736	0.3736	0.3736	0.379	0.3736
Depth of grooves..inches.	0.06	0.06	0.06	0.06	0.07	0.07	0.06
Width of lands ..inches..	0.15	0.15	0.15	0.15	0.15	0.175	0.15
Twist ..... calibers..	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 25	1 in 40 to 1 in 20
Total capacity of bore, cubic inches	14,125	28,977	50,049	55,829	121,487	12,554	13,947
Capacity of powder chamber, cubic inches	3,597	7,064	12,114	12,798	29,341	1,990	2,636
Length of powder chamber, inches	50.75	65.09	77.33	78.58	106.06	15.75	20.8
Travel of projectile in bore, calibers	25.66	27.51	27.58	31.29	28.37	7.66	8.225
Powder charge:							
Kind	(a)	(b)	(c)	(d)	(d)	(e)	(e)
Weight ..... pounds..	125	259	450	487	1,060	80	105
Density of loading	0.9619	0.9797	1.0285	1.0535	1	1.1128	1.1026
Projectile:							
Weight ..... pounds..	300	575	1,000	1,000	2,370	8,000 / 1,000	800 / 1,000
Ratio to weight of piece..	1 to 108	1 to 117	1 to 115	1 to 129	1 to 118	1 to 40*	1 to 36
Pressure in powder chamber, pounds per square inch	37,000	37,000	37,000	38,000	37,000	27,500	30,000
Muzzle velocity..feet-second.	1,950	1,675	1,975	2,100	1,675	1,020	1,140
Muzzle energy .... foot-tons..	7,907	15,548	27,040	30,570	64,084	5,770	7,207
Penetration in steel:							
Muzzle ..... inches..	16.0	20.4	24.9	27.1	33.8	8.2	9.7
3,500 yards ..... inches..	10.6	14.6	18.7	20.6	27.5	.....	.....

a U. R. brown prismatic.
b V. U. brown prismatic.
c V. P. brown prismatic.
d Brown prismatic.
e V. M. brown prismatic.

TABLE II.—*Breech-loading ordnance, U. S. Naval Service.*

[Guns of 4 inches caliber and upward.]

	Main battery guns, steel.								
	Rapid fire.	Rapid fire.	Mark III, 30 calibers.	Mark III, 40 calibers.	Mark III, 35 calibers.	Mark III, 40 calibers.	Mark II, 35 calibers.	Mark I.	Mark I.
Caliber .....inches..	4	5	6	6	8	8	10	12	13
Weight:									
Pounds	3,400	7,000	10,800	13,370	29,400	34,000	61,900	101,300	135,500
Tons	1.5	3.1	4.8	6.0	13.1	15.2	27.6	45.2	60.5
Total length .....feet..	13.7	17.4	16.3	21.3	25.4	28.7	31.2	36.8	40.0
Length of bore ..calibers..	39.4	38.3	30.62	40.62	36.31	41.31	35.49	34.93	34.85
Diameter over powder chamber .....inches..	13.0	16.5	20.5	21.0	28.75	28.75	39.00	45.0	49.0
Diameter of powder chamber.....inches..	4.44 4.09	5.55 5.10	7.0	7.0	9.5	9.5	12.5	14.5	15.5
Thickness over powder chamber .....calibers..	1.03	1.06	0.97	1.00	0.91	0.91	1.06	1.05	1.08
Number of cylinders comprised in the thickness..	2	2	3	3	3	3	3	3	3
Rifling:									
Number of grooves....	30	30	24	24	32	32	40	48	52
Width of grooves inches.....	0.279	0.349	0.485 0.415	0.485 0.415	0.485 0.415	0.485 0.415	0.485 0.415	0.485 0.415	0.485 0.415
Depth of grooves, inches.....	0.025	0.025	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Twist .....calibers..	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25
Total capacity of bore cubic inches.....	1,994	3,965	5,552	7,256	15,548	17,564	30,350	51,355	64,857
Capacity of powder chamber .....cubic inches..	329	655	1,299	1,299	3,176	3,176	6,831	12,043	15,059
Length of powder chamber .....inches..	25.38	32.0	33.99	33.99	45.05	45.05	57.17	74.14	80.88
Length of rifled bore.do....	128.12	164.4	147.26	207.26	242.77	282.77	294.91	343.12	370.46
Travel oprojectile in bore inches.....	132.12	168.0	149.76	209.76	245.47	285.47	298.08	346.06	373.58
Weight of powder charge (brown).....pounds..	14	30	47	47	115	115	240	425	550
Projectile:									
Weight.....do....	33	50	100	100	250	250	500	850	1,100
Ratio to weight of piece	1 to 103	1 to 140	1 to 108	1 to 134	1 to 118	1 to 136	1 to 124	1 to 119	1 to 123
Pressure in powder chamber....tons per sq. in....	15	15	15	15	15	15	15	15	15
Muzzle velocity, feet-second	2,000	2,250	2,000	2,150	2,080	2,150	2,100	2,100	2,100
Remaining velocity 2,500 yards .....feet-second...	1,246	1,374	1,402	1,507	1,615	1,670	1,724	1,777	1,805
Muzzle energy .foot-tons..	915	1,754	2,973	3,204	7,498	8,011	15,285	25,985	33,627
Penetration in steel at muzzle.....inches..	7.18	9.0	10.27	11.38	15.61	16.10	20.10	24.16	26.66

Improved ballistic effects have been obtained with charges of smokeless powder, as the following results show. The data given for the 12-inch gun of 37.83 calibers length of bore is that anticipated from results with similar guns. The 10-inch gun was fired with powder originally procured for the 8-inch:

Gun.	Density of loading.	Charge.		Pressure.	Muzzle velocity.	Muzzle energy.
		Powder.	Projectile.			
		Pounds.	*Pounds.*	*Pounds sq. inch.*	*Feet second.*	*Foot tons.*
Naval 4-inch R. F.....	.....	5.3 (M. N. 2).....	33	33,600	2,160	1,068
Naval 5-inch R. F.....	.....	13.4 (M. N. 3).....	50	34,950	2,578	2,310
Naval 6-inch (40 caliber).....	.....	26.0 (M. N. 6).....	100	31,250	2,469	4,230
Army 8-inch (32 caliber).....	.....	50 German	300	38,175	2,162	9,720
Army 10-inch (32 caliber).....	.....	80 German	571	34,880	1,960	.....
Army 12 inch (34-caliber).....	.....	221 (French B. N)	999	35,730	2,010	28,006
Army 12-inch (37.83 caliber)	0.503 0.595	231 (German) ..... 275 (French B. N.)	1,000	36,000	2,200	33,550

Better results are obtained in the same gun with charges of smokeless powder weighing one-half or less than one-half of the brown powder. If the same limit of pressure is retained the smokeless powder gives much increased velocities, or it will give the same velocity with considerably reduced pressure. In heavy guns these advantages will no doubt be utilized in deriving increased powder and maintaining high pressures. In field guns, however, there appears to be room for a reduction of pressure in using smokeless powder. And this, combined with improvements in the qualities of the forged steel—possibly using nickel steel—may make it feasible to pass from the compound to the simple mode of construction for field guns. For example, the 3.2-inch field gun has a thickness of 0.75 caliber over powder chamber. Then, Fig. 1, $P = 0.583\ \theta$, and if $\theta = 60{,}000$ pounds, the gun, as a simple tube, would support a powder pressure of about 35,000 pounds per square inch.[1]

Drawings showing typical longitudinal sections of the different classes of these guns are given in Plate III. The difference between the 12-inch seacoast gun, model 1892 (37.83 calibers) and that of model 1888 (34 calibers), Plate II, illustrates very plainly the changes toward simplification of structure and increased longitudinal stiffness brought about during that period by improved facilities and experience in the manufacture of steel forgings whilst meeting the demand for increased length of bore. Although the later model is $3\frac{1}{3}$ feet longer it contains a total of eleven parts in the body of the gun as against twenty-one in the model 1888.

The 8-inch gun shown in Plate III contains but four parts in the body. This gun is made of nickel steel, containing 3 to 3.25 per cent of

[1] *Foreign guns.*—The following table gives data relating to several of the more powerful guns adopted or proposed in foreign services, according to published notices. The results are taken to show the best attainments of the several guns; those of the Japanese (Canét) and two French navy (Ruelle) guns are for charges of smokeless powder, and the remainder for brown powder.

Service.	Maker.	Caliber.		Weight.	Length of bore.	Charge.		Muzzle velocity.	Muzzle energy.
						Powder.	Projectile.		
		Cm.	*Inches.*	*Tons.*	*Calibers.*	*Pounds.*	*Pounds.*	*Foot-seconds.*	*Foot-tons.*
French navy	Ruelle	30	11.81	45.0	45	(S)	625	2,625	*a*29,890
Do	do	34	13.39	57.1	42	(S)	926	2,460	*a*38,740
Japanese navy	Canét	32	12.60	65.0	40	317(S)	993	2,386	39,187
British navy	Woolwich		13.50	67.0	30	630	1,250	2,025	35,560
Do	Armstrong		16.25	100.5	30	960	1,800	2,148	57,570
Italian navy	do	43	17.00	114.3	27	900	2,000	1,992	55,030
Italian seacoast	Krupp	40	15.75	119.0	32	847	2,315	1,900	57,930

a Annual of the Office of Naval Intelligence (U. S.), 1892. The weights of powder charges are not given. It is intended, the notice further states, to build the 30-centimeter guns with a bore of 50 calibers length in future.

It is currently reported that the English are making 12-inch guns of wire-wound construction, but if any firings have been made with a gun of this description the results are not available.

nickel. The test pieces from the completed forgings gave the following noteworthy results, which show a gain of from 25 to 30 per cent over the elastic properties of the gun steel now in general use:

Forgings.	Specimen.		Elastic limit.	Tensile strength.	Elongation after rupture.	Construction of area.
	Length.	Diagram.				
Tube:	*Inches.*	*Inches.*	*Pounds □″.*	*Pounds □″.*	*Per cent.*	*Per cent.*
Average	2	0.496	58,620	92,200	21.23	41.64
Minimum	2	0.496	56,925	90,562	17.70	28.91
Inner jacket:						
Average	2	0.496	58,820	100,185	20.52	46.00
Minimum	2	0.496	55,890	98,325	19.50	41.15
Outer jacket:						
Average	2	0.496	70,560	110,813	20.42	46.29
Minimum	2	0.496	70,040	110,725	19.50	45.01

The use of longer cylinders requires increased care and appliances for the shrinkage operations to avoid undue longitudinal strains arising from unequal "gripping" of the heated piece on cooling. It is aimed in assembling the guns to produce progressive contact of the two surfaces by artificial means of cooling carried evenly along from end to end. In connection with the 8-inch gun last mentioned, Mr. William Sellers has undertaken to provide a special heating apparatus which is intended to give full control in this regard, and to be applied to again separate the parts after they have been shrunk together; and illustrate how a damaged or eroded tube may be replaced by a new one.

IV.—RESISTANCE AND SHRINKAGES OF BUILT-UP, FORGED STEEL GUNS.

Experiment has shown the remarkable conformity of results obtained in the actual manufacture of these guns with those indicated by the formulas applied in their construction. Each gun is assembled with a determined set of shrinkage values based upon the qualities of metal contained. The estimation of these values is facilitated in dealing with all steel guns in which a uniform value may be taken for the modulus of elasticity of the steel throughout the structure. Taking this modulus in connection with the minimum elastic properties of the metal, it is the practice in the U. S. Army Ordnance Department to deduce for each kind and caliber of gun a typical set of shrinkages to be used in the construction of other similar guns. The resistance computed for the type gun will be the least of its kind, whilst the higher elastic qualities of the steel generally obtained will result in giving a greater resistance without necessitating any change of prescribed shrinkages. The tangential resistance of the guns given in Table I is computed upon this basis. The values used for the elastic limits of metal in the different classes of guns, as given below, represent the minimum average qualities found or admitted in acceptance of the forgings, except in the case of outside hoops, where a reduction of about 10 per cent on the actual elastic limit is made as a further factor of safety, inasmuch as these

hoops are without exterior support in the structure. The tests of the metal show that a uniform value of 30,000,000 pounds (13,393 tons) may be taken without sensible error to represent the modulus of elasticity (E) of the steel throughout the series. The average ultimate physical properties of the metal are also annexed in the following table:

Cannon forgings.	Specimen.		Elastic limits.		Tensile strength.	Elongation after rupture.	Contraction of area.
	Length.	Diameter.	Load $\theta=\rho$.	Extension per inch $\theta \div E$.			
Field:	*Inches.*	*Inches.*	*Pounds* □″.	*Thousandths.*	*Pounds* □″.	*Per cent.*	*Per cent.*
Tubes	2	0.505	44,800	1.4933	86,000	22	40
Jackets	2	0.505	49,280	1.6427	93,000	20	35
Siege:							
Tubes	3	0.564	42,000	1.4000	78,000	18	30
Jackets	3	0.564	48,160	1.6053	86,000	16	27
Hoops	3	0.564	48,160	1.6053	90,000	18	.....
Seacoast:							
Tubes	3	0.564	41,440	1.3813	78,000	17	30
Jackets	3	0.564	43,680	1.4560	85,000	16	27
Hoops:							
Inner	3	0.564	50,400	1.6800	93,000	13	.....
Outer	4	0.564	45,920	1.5307	93,000	13	.....

The formulas employed[1] are based upon the principle that the displacement of metal fiber in the structure, due to the combined action of the stresses of tension and pressure, shall at no place exceed the elastic limit of displacement determined by free tests of the metal. The fundamental formulas are those of Lamé, modified in their application from the methods proposed by Maj. Clavarino, of the Italian Army. They have also been very ably discussed in their application to gun construction from a different standpoint by Col. Virgile, of the French Army. A general statement regarding the application of the present formulas to determine the resistance and shrinkages for a forged steel built-up gun is as follows:

The given quantities are the radial dimensions of the simple cylinders, the modulus of elasticity, and the elastic limits of the metals, the two former being fixed and the latter independent constants to the extent that any values below the given limits may be substituted. The constants being given, the primary object will be to deduce such shrinkages for the assemblage of the simple cylinders as will put the structure as a whole in the best condition to resist the powder pressure, or, as we may say, ordinarily to afford a maximum resistance to pressure in the bore. To this end, and in order to first determine the pressures which it will support, the system is supposed to be completely assembled and the pressures determined, and thereupon the shrinkages commensurate with such pressures are deduced. It then only remains to apply these shrinkages in assembling the system in order that the stated conditions of pressure or resistance may be realized. Two extreme states of equilibrium, corresponding to the limits of strain in the system, must be considered, viz: First, the state of action in which

[1] Notes on the Construction of Ordnance, No. 59, Ordnance Office, War Department, Washington, July 23, 1891.

the resistance to pressure in the bore is determined by supposing each simple cylinder subjected to the maximum or at least the greatest useful interior pressure that it will support. This state corresponds to the moment of firing, and the computed resistance must be fully equal to or greater than the anticipated service pressure. Second, the state of rest which exists when there is no pressure in the bore. This is the normal state of the system, and the strains are relatively small, except at the surface of the bore, where overcompression is liable to occur, and the limit of strength for the system in this regard will be determined by the consideration that the pressure acting at the first contact surface upon the exterior of tube shall not exceed the safe pressure for that cylinder when there is no interior pressure acting.

12-INCH B. L. RIFLE, STEEL, MODEL 1888—PLATES I AND II.

Taking this gun as an illustration of the methods, Pl. II shows the curves of resistance (tangential and radial) and of compression of bore, the latter being arranged to show the partial compressions due to the shrinkage of each layer of cylinders. These compressions are measured after each layer is applied and a means is thus afforded for an independent check upon the measured shrinkage so that a correction of subsequent shrinkages may be made if necessary. The shrinkages are written to show the length over which each given value is to be applied. The values are stated, for shop work, in absolute dimensions and indicate the excess of diameter to be given; they are the products obtained from multiplying the relative values (shrinkages per inch of diameter), as determined by the formulas, by the reference diameter of the shrinkage surface (interior diameter of applied cylinder).

To obtain all the data, the whole length of the gun is taken in sections. The computations are made for each section and the quasi independent results are combined to obviate undesirable inequalities of strains in passing from one section to another and to give as far as practicable equal shrinkages on diameters common to two sections, whilst not overlooking the primary consideration to preserve in all cases a sufficient elastic resistance to withstand anticipated powder pressures. The lengths of the sections, of which thirteen are taken for this gun, are governed by changes in the number of layers and sectional dimensions from part to part. That one which embraces nearly the whole length of the powder chamber will be taken for further illustration.

Section of powder chamber.—The intensities of the pressures and strains for the states of "action" and "rest" respectively are graphically shown in Fig. 2, Pl. I, being plotted from values given in the following table (intermediate values of the radii have been introduced only for the purpose of determining a third point in the curves pertaining to each cylinder, for graphic delineation):

TABLE III.—*Summary pressures and strains, powder chamber, 12-inch rifle.*

Designation of parts.		State of action.		State of rest.			Remarks.
		Pressures.	Strains.	Pressures.	Strains.		
		P	θ	P'	θ'	$\frac{\delta r}{r}=\frac{\theta'}{E}$	
Tube	Interior, $R_0=7.1$	23.66	18.50	0.—	—17.98	—.0013425	
	$r=9.0$	17.19	9.87	3.39	—13.45	.....	
	Exterior, $R_1=11.0$	13.66	5.17	5.25	—10.99	—.0008206	First contact surface.
Jacket	Interior, $R_1=11.0$	13.66	15.08	5.25	— 1.08	—.0000811	
	$r=14.0$	9.04	8.92	4.78	— 1.71	.....	
	Exterior, $R_2=16.8$	6.75	5.86	4.55	— 2.00	—.0001493	Second contact surface.
A Hoop	Interior, $R_2=16.8$	6.75	22.50	4.55	+14.63	+.0010924	
	$r=18.0$	5.00	20.17	3.42	+13.11	.....	
	Exterior, $R_3=19.65$	3.12	17.66	2.18	+11.46	+.0008556	Third contact surface.
B Hoop	Interior, $R_3=19.65$	3.12	20.50	2.18	+14.31	+.0010685	
	$r=21.00$	1.72	18.63	1.20	+13.00	.....	
	Exterior, $R_4=23.10$	0.—	16.34	0.—	+11.40	+.0008512	

NOTE.—P and θ express values in tons per square inch and $\frac{\delta r}{r}$ the tangential displacement (contraction or extension) of metal per linear inch at the extremities of given radii.

In the state of action, which supposes a pressure of 23.66 tons acting within the bore, the interior of *each* cylinder is tangentially strained to the elastic limit adopted, except the jacket, viz: Tube, 18.5; jacket, 15.08 (limit=19.5); A-hoop, 22.5; and B-hoop, 20.5 tons.

In the state of rest, with no pressure in the bore, the pressures at the contact surfaces fall to 5.25, 4.55, and 2.18 tons, respectively, whilst the stresses and strains are balanced by compressions in the tube and jacket against extensions in the two hoops, the maximum values being: Compressions of 17.98 tons in tube and 2 tons in jacket, against extensions of 14.63 tons in A-hoop and 14.31 tons in B-hoop.

To utilize the full elastic strength of this section of the gun the tube should be compressed to the limit 18.5 tons. A lower limit is, however, purposely taken to provide for reaming out the gun at a future time to insert a lining tube and prevent overcompression when that is done. The present compression (17.98 tons) will be increased to the limit (18.5 tons) if the completed gun is reamed out to a diameter of 16 inches, as proposed for the exterior of the liner when introduced.

In estimating the pressures for the state of action we begin with the outside cylinder, find what interior pressure it will stand, then proceed with each cylinder inwards, and finally get the resistance of the tube (and of the gun) to interior pressure, when supported by a pressure on its exterior surface due to the combined resistance of all the exterior cylinders.

The pressures for the state of rest are derived by considering the pressure in the bore removed. Then, knowing by what amount the pressure at each contact surface is changed by the given change of pressure in the bore, we obtain the pressures for the state of rest by deducting the changes so determined at the contact surface from the respective pressures existing at the same surfaces in the state of action.

Having thus deduced the pressures required in the state of rest to develop the maximum resistance when pressure is applied in the bore,

it remains to find the shrinkages which may be defined as *the difference which must be made in the diameters of the cylindrical surfaces before assemblage, such that, when assembled, the given pressures for the state of rest will be produced at the contact surfaces.*

The shrinkages.—Fig. 1, Pl. I, illustrates the manner in which the diameters of the cylinders are changed by the shrinkage. The shrinkages are plotted on the right of the median line. On the left of this line we have the positions of the contact surfaces as each successive cylinder is applied, also the corresponding compressions of the bore, and finally the extension of the exterior of B-hoop. The actual changes are much exaggerated in the drawing. The reference (zero) point for each contact surface is the interior diameter of the applied cylinder. In the completed state of the structure the contact surfaces are in the places marked "final position," and the pressures thereon produced are those required in the state of rest. In these positions, as seen from the drawing, the several shrinkage values are made up as follows: The first by the contraction of the exterior of tube minus the contraction of interior of jacket; the second by the contraction of exterior of jacket plus the extension of interior of A-hoop; and the third by the contraction of exterior of A-hoop plus the extension of interior of B-hoop. Hence the rule:[1] At each contact surface *the shrinkage is equal to the contraction of the exterior of the inner cylinder increased by the extension of the interior of the outer cylinder, as caused by the action of the pressures pertaining to the complete system in the state of rest.* At the first contact surface the interior of jacket is contracted instead of extended; hence the second term is subtractive.

The shrinkage values written on the drawing are computed by the usual formulas, based upon the following method of assemblage: The interior of each cylinder to be applied is finished bored to the prescribed diameter. This is taken as the reference diameter, and then the surface on which it is to be applied is turned to the excess prescribed for the shrinkage.

The stages of assemblage are: First, the jacket is shrunk upon the tube; second, the A-hoop is shrunk upon the combined jacket and tube; and, third, the B-hoop upon the combined A-hoop jacket and tube. It is to be observed that the second and third shrinkages are turned upon the exterior of jacket and A-hoop, respectively, when the metal is in a state of extension due to previous shrinkage.

If the preceding rule for shrinkages is applied with the values of the strains, $\frac{dr}{r}$ taken from Table III, we would have

$$\varphi_1 = + .0008206 - .0000811 = .0007395$$
$$\varphi_2 = + .0001493 + .0010924 = .0012417$$
$$\varphi_3 = - .0008556 + .0010685 = .0002129$$

[1] Observe that as regards displacements of exterior surfaces contractions will be considered positive and extensions negative, and for displacements of interior surfaces extensions will be positive and contractions negative.

which, except the first, are smaller than the formulated values given on the drawing. The present values would be in fact those to be applied in construction in case *all* the shrinkage surfaces were prepared before any of the cylinders had been assembled, since they relate to the effect of the pressures upon each cylinder supposed entirely free, and indicate the changes in dimensions from the neutral (free) position of each cylindrical surface. In order to connect these values with the formulated values we must add the extensions produced at the exterior of jacket and A-hoop when assembled. These extensions as computed are: +.0002252 and +0.0010133. Adding the first in φ_2 and the second in φ_3, we have the formulated values 0.001467 and 0.001226. The first shrinkage is the same in either case, since this shrinkage is prepared in any event with the tube and jacket in a free state.

The sufficiency of the formulas used in these computations has been proved in a number of ways by experiment. It is difficult to state just what pressures are produced in firing because the means of measuring them are not exact. However, the many rounds fired from the guns do show that if the powder pressures, as registered by the pressure gauges, do not exceed the resistance estimated by the formulas the guns will not be enlarged. On the other hand, there were two solid cast-steel guns, understood to be without initial tension, made in 1887–'88 which, from the tests of metal, were qualified to withstand an interior pressure of 10 to 13 tons. These guns were subjected to firings with the service charge giving a registered pressure of about 15 tons. The results were that one of them (Bessemer steel casting) was burst at the second round, and the other (open hearth casting) showed a perceptible enlargement after ten rounds, and a still further enlargement after twenty rounds.

Much more exact verifications, by means of the measured displacements, are possible and have been made in connection with numerous shrinkage tests of hoops and in building up short sections of different guns in full dimensions. Particular reference may be made to the section of an 8-inch gun tested in this way at the West Point foundry in 1885. The section was about 8 inches in length and built up of four cylinders analogous to the 12-inch gun section shown in Figs. 1 and 2, Pl. I. The displacements of diameters and lengths caused by each shrinkage were carefully measured and in every instance showed a close agreement with the indications of the formulas. For example, the anticipated total compression of the 8-inch bore was 0.0129 inch, and its measured compression 0.0131 inch; the anticipated extension of the exterior of the outer hoop (31.5 inches) was 0.0285 inch, and its measured extension 0.0276 inch. These culminating measurements of the series thus showed a difference of less than 2 per cent between the actual and anticipated results.

V.—LONGITUDINAL RESISTANCE.

The longitudinal strain in the breech of the gun on firing is assumed

to be uniformly distributed over the cross section of the jacket or block-carrying cylinder. Two factors combine to produce this strain; one, the longitudinal pull or elongation caused by the direct thrust of the pressure in the bore on head of block, and the other, the displacement in longitudinal direction caused by the pressures which act normally upon the interior and exterior of the jacket. The latter may be either an elongation, tending to increase the strain due to the direct thrust, or a contraction, tending to diminish it, depending upon the relative intensities of the normal pressures. Employing the common notation to distinguish pressures and radii, the stresses per square inch on cross-section of jacket caused by the two sources of strain indicated are expressed as follows:

$$\text{Direct thrust, } \frac{P_0 R_0^2}{R_2^2 - R_1^2} \quad \text{Normal pressures, } \frac{-P_1 R_1^2 + P_2 R_2^2}{3\,(R_2^2 - R_1^2)}$$

The first expresses the aggregate pressure on head of block, divided by an area of cross section of jacket. The second expresses a longitudinal stress which will be positive or negative according as $P_1 R_1^2 <\text{or}> P_2 R_2^2$. Its greatest positive value correponds to $P_1=0$; and, in general, an excess of *exterior* normal pressure tends to elongate the block-carrying cylinder and increase the direct thrust due to the powder pressure.

Fig. 3 shows a section about the breech of tube of the 12-inch rifle already discussed with reference to tangential resistance. We will suppose that the same pressure, 23.66 tons, which determined the tangential resistance is within the bore, in noting, however, that as the service pressure will not exceed 17 tons all estimates of strains based on a pressure of 23.66 tons will be correspondingly greater than is to be anticipated under service conditions.

The extreme conditions for longitudinal strain will be imposed if we consider that the interior surface of the breech recess at *d* is subjected to no pressure. Then the section of jacket at *a*, which is the thinnest portion in the zone *a–b* where there is no interior pressure, will be subjected to the greatest longitudinal strain. In the zone *a–c* the metal is solicited by the pressure P_1 and P_2 and the longitudinal stress derived by substituting the given values in the preceding expression for "normal pressures" amounts to +0.56 tons per square inch. But in the zone *a–b* the metal will be solicited by the strain due to the exterior pressure $P'=4.55$ tons alone, which will induce a greater elongation. Calling L the longitudinal stress per square inch of cross section and adding the term relating to the direct thrust from the powder pressure, the total stress per square inch in the section at *a* is expressed by

$$*L = \frac{P_0\, R_0^2}{R^2_2 - R^2_1} + \frac{2P'\, R^2_2}{3(R^2_2 - R_2{}^1)}$$

---

*This symbol for stress is to be understood as used in the same sense as θ is used in connection with the tangential resistance. The general form of the equation may be written : $L=(1+1')\,E$, in which 1 and 1′ stand for the longitudinal displacements of metal, corresponding to the two terms in the second member, and E is the modulus of elasticity.

and, substituting given values

$$L = 6.7 + 4.80 = 11.50 \text{ tons per square inch.}$$

The elastic longitudinal resistance of the jacket being 19.5 tons (elastic limit of metal), this stress is seen to be well within limits, and is relatively less severe than the tangential stresses in the gun for the same extreme state of action.

Flexure of jacket.—There will be a longitudinal flexure of the jacket in the zone *a–b*, tending to produce a cross strain, caused by the difference of radial extension of interior of jacket in this zone and the zone *a–c*. The latter is carried outward by the pressure in the bore, whilst the former may in the extreme case be supposed to remain in the original state of compression belonging to the state of rest as induced by the shrinking of the hoops around it. This flexure or difference of extension amounts in this gun (for $P_0 = 23.66$ tons) to the following:

Contraction per inch at interior of zone *a–b*, computed for state of rest...	0.000863
Extension per inch of interior of zone *a–c*, computed for state of action...	0.001227
Sum equals total flexure	0.002090

The control of this value lies largely in the first set of figures, and the shrinkage of the hoops is made comparatively light over the breech recess to reduce the original compression and not allow the total flexure to exceed a relative value of about 0.002, which has been somewhat arbitrarily adopted by the Army Ordnance Department as the maximum to be allowed in the construction of this and similar guns. The hurtfulness of the cross strain arising from this flexure in combination with the strain at the root of the first thread in the breech is alleviated by lengthening the distance from *a* to the first thread. And the amount of the flexure may itself be reduced by using a form of thread which will cause a radial pressure to be exerted by the block, and thus expand the breech to a certain extent when the zone *a–c* is expanded.

Form of thread.—The consideration last mentioned is one of those adduced in favor of the V-shaped thread, as generally used, in preference to the ratchet form of thread. The two forms of thread are illustrated in Fig. 3. The rearward thrust of the block produces a pressure between the faces of threads of block and breech which reacts in a direction normal to the face of the thread. With the V thread this pressure is divided into two principal components, one acting radially to expand the breech and compress the block, whilst the other, parallel to the axis, acts to elongate the jacket as a whole and as a shearing force on the thread. It may be seen that there is no reduction of the component which tends to elongate the jacket, brought about by the shape of thread, and that the radial component of pressure is due to the wedging action of the V thread. The vertical face of the ratchet form of thread would receive the same aggregate horizontal thrust as a V thread of the same height. It would, however, not only give no radial

component of pressure, but in addition, when engaged with the thread on the block, would by its form of face interlock with the block and prevent an expansion of the breech at the first thread, which would practically shorten the zone of flexure before alluded to, and increase the intensity of the cross strain, particularly at the root of the first thread.

It is important that the threads on block and in breech should be uniformly strained through the whole length of the screw, under the maximum thrust. Considering the ratchet form, if the two threads have the same pitch the strain will be most severe on the first thread, and those toward the rear of the breech will render little or no assistance. The condition for uniform resistance requires the block thread to have a somewhat greater pitch than the breech thread. Suppose this to be arranged, with the rear threads in bearing and an increasing clearance toward the front, preparatory to receiving the thrust on the head of block. The action of the thrust will then cause the breech to be elongated and the block to be compressed, and these elongations and contractions being directly proportional to the distance from the rear thread, the increasing clearance spaces toward the front will be proportionately closed and all the threads will be brought into bearing. Conversely, and in the absence of this difference of pitch, the strain on the threads would fall off rapidly from the front toward the rear. The difference of pitch to be given should depend upon the force of the thrust and the elastic properties of the metal. In practice the required clearances are sometimes provided by first making the two threads of the same pitch; then dressing off the rear faces of the threads on the block by amounts decreasing from the first thread toward the rear. An arrangement of this nature may be considered almost indispensable with the ratchet form of thread. With the V thread, however, accompanying the expansion of breech about the front threads, and the ability of the faces to slide one within the other, an approximation to uniformity of strain may be reached even without an allowed difference of pitch. Too much wedging action would tend to cause sticking of the block and render it difficult to unscrew after firing. Hence in practice the angle given between the faces of the thread in the heavier guns is limited to a maximum of about 105°. In the lighter field and siege guns, in order to secure a certain relief or absolute height of thread, an angle of about 82° is used.

VI.—BREECH MECHANISM.

Loading at the breech instead of the muzzle is a feature universally adopted for modern guns. The increased complexity of construction is much more than compensated for by greater facility of loading and increased rapidity of fire, together with a better utilization of the powder charge and higher and more uniform ballistic results. The essential features of every breech mechanism, arranged in their order of importance,

and by which the various forms in use may be distinguished, comprise: (1) a removable block which shall be strong and safe in its connection with the gun when fired; (2) a means of preventing the escape of the powder gases, and (3) a ready means of manipulating the block. It is highly important also that it should be arranged to prevent premature discharge. The chief distinction and that which fixes the generic name of the system lies in the form of the block and the mode of its connection with the gun in resisting the shock of discharge. The breech mechanism of the heavier guns in use are thus all classified under two general systems, viz, the screw, in the prolongation of the bore at the breech, and the sliding wedge, through openings in the sides of the breech at the rear of the powder chamber. These are more generally known as the French and the Krupp systems, respectively, from the sources of their practical development into successful working plans. The different patterns of rapid-fire guns are also, with few exceptions, embraced in these systems.

THE SCREW SYSTEM.

In this, the usual form of breech opening is a cylindrical, threaded surface, which is slotted in sectors to the depth of the thread, to remove one-half of the thread from the breech and one-half from the block. When the block is inserted, the threaded sectors thereon slide in the smooth sectors of the breech, permitting rapid motion until the block reaches the place where a part of a turn equal to the width of one sector will engage the threads and complete the insertion. Occasional plans are found where the slotting is omitted, as in the Armstrong rapid-fire guns, having a full screw made upon conical surfaces; and in the Brown segmental wire-wound gun, previously mentioned, where the block is of large diameter and is inserted with a full thread on four complete turns.

The screw system permits the gas check to be attached either to the block, or, in the form of a ring or cup, to be placed in a recess made in the tube at the base of the powder chamber. The first plan, which admits of a ready examination of the check at all times, and requires less cutting in the tube, is that usually followed. Examples of this are to be found in the popular De Bange check, to be described later; also, a steel ring of L section, clamped to the block by a head piece as used in Italy, Fig. 4, Pl. VIII; and in the Freyre check, which consists of a steel ring with thin edge, that is forced outward against the bore by the pressure of the gas upon a conical spindle head within the ring, Fig. 5, Pl. VIII. An example of the second plan, using a copper ring of peculiar form, is found in the guns of the French marine, model 1884, Fig. 6, Pl. VIII.

The remaining mechanism of the breech comprises means for manipulating the block; for supporting it when withdrawn; for locking it to prevent premature unscrewing, and a safety device against premature

discharge, comprising a vent cover (or lock guard), worked automatically by other necessary movements of the block. When withdrawn, the block must be swung clear of the breech opening. This is accomplished by supporting it either upon a console, or within a carrier ring, usually hinged to the side of the breech of the gun.

In manipulating the block, the greatest power to be applied is that required in the first motion of unscrewing after the discharge. In light guns this is secured by a simple lever, whilst in heavy guns gearing, worked by hand power, and sometimes by machine power on shipboard, is employed. Examples of various forms of this mechanism are illustrated in the plates.

The 8-inch breech mechanism, Pl. v, is taken for description as a type of the slotted screw breech closure with plastic gas check, commonly used for heavy guns in our service, as follows:

The breech of the gun is constructed as in the 12-inch seacoast gun, model 1892 (Pl. III), to allow the jacket to be assembled upon the tube from the front, or, as it is technically called, by "rear insertion" of the tube. The breech sleeve is then screwed into the jacket from the rear, and the breech thread is cut upon its interior surface instead of directly in the jacket. In order to secure an easy insertion of the sleeve in the jacket and a close fit circumferentially, the surfaces on which the corresponding threads are cut are made slightly conical. The sleeve is screwed tightly home against the copper gasket ring *r*, and is stayed by the securing pins *s*.

The principal detachable parts of the breech mechanism are: The block A; gas check, B, and spindle, C; rotating ring and gear arm, D; pinion wheel and shaft, E; breech plate, F; console, G, with translating screw, H, and latch, L; and the vent cover M. The crank arm N, having a spring catch, *n*, is applied to rotate the block, and the crank O works the translating screw. The latch P secures the console, with block, in place when opened and swung clear of the breech. The metal parts generally are made of forged steel, except the breech plate, which is an annealed steel casting, and the bronze bushings *f* and *f'* fixed in this plate. In future constructions it is contemplated to make the breech plate of bronze and do away with the separate bushings.

To open the breech, first raise the spring catch *n* and turn it 180° to release the crank N; next turn this crank until it is stopped by the mechanism, one and three-fourths turns to the right to engage the translating stud *a'* of the block in the open thread of the translating screw H, and to bring the grooves *a* of the block opposite the guide rails *g* of the console; then turn the crank O until it is stopped by the mechanism, about three turns to the left, ending with a quick motion, to bring the block fully out upon the console and to release the latch L. The console will then (with continuous motion) be swung by hand to the right, to engage the securing latch P in a catch on the side of the breech, which will hold it with the block in the open position.

To close the breech, release the latch P by hand, and swing the console to the breech, to engage the latch L; reverse, first the motion of the crank O, then of the spring catch *n* (180°), and finally, of the crank N, as made in the opening movements.

Description of parts.—The threaded portions of exterior of block and interior of breech are each divided into six equal sectors, three smooth and three threaded, the threaded sectors being engaged when the block is closed. The cylindrical portion of the exterior of the block at the rear fits snugly in the breech plate and rotating ring, and slides through them when the block is moved out or in. Near the bottom of the block are two longitudinal guide grooves, *a*, which receive the guide rails *g* of the console, and terminate in the body of the block well to the front. The stud *a'*, affixed to the block, engages in the open thread of the translating screw H, when the block is turned for withdrawal, and serves by the turning of that screw to move the block upon the console.

The gas check rests in the conical mouth of the powder chamber, between the block and the head of spindle, where it is compressed and forced out laterally by the pressure in the bore. The front and rear gas check cups *b* are made of special steel of high elasticity and inclose the pad between them; their outside diameters are made slightly smaller than the bore, so as to prevent contact, and they are lined with cups of sheet copper, *b'*, to prevent cutting the pad at the outer surface. A small steel split ring, *b''*, is placed over the joint of the rear cup around the spindle, to prevent squeezing the pad into this joint. The pad is made of asbestos and tallow molded into shape under heavy pressure, and covered with canvas. The escape of gas is prevented by the spreading of the pad under the pressure in the bore.

The spindle is perforated axially for the vent through which the charge is ignited by an obturating electric primer placed in the rear end of the spindle. The front end of the vent is bushed with copper, to be removed when worn by erosion. The nuts *c* serve to adjust the initial pressure of the head of spindle on the gas check. These nuts rest upon the pile of anti-friction washers, *c'* (alternate steel and bronze), whose office it is to allow the block to rotate around the spindle in making the sixth of a turn for opening, and utilize the power of the screw on the block to start the gas check from its seat without rotation. This movement reduces the power required to rotate the block, since it avoids the frictional resistance to rotation that would be caused by attempting to turn the pad when expanded in the bore.

The rotating ring, with gear arm, D, encircles the block, and has a lug *d d* projecting inward, which fits into and slides along a groove of corresponding dimensions in one of the smooth exterior sectors of the block. The block is, therefore, compelled to turn with the ring when the latter is turned by power transmitted from the crank N through the pinion E. The spring catch *n* is reversible through 180°. The stop end has a beveled and a straight side. In the locked position the straight side is in bearing in the socket of breech plate, and prevents the crank from turning or the block from unscrewing. In the unlocked position of the block the crank arm is horizontal, and the spring catch enters the socket *n'* in the head of one of the breech-plate bolts and holds the crank arm in that position. When the arm is in motion the beveled side of the catch is turned towards the sockets and rides over them.

The breech plate F serves to connect the breech mechanism and console to the gun, carries the gears that give rotation to the block and covers and protects the smaller parts from weather and accident. The rotating ring rests and revolves in the bushing *f*, which is fixed in the plate. The plate is fastened to the breech of the gun by the screw-bolts *f'*, eleven in number. The lugs *f''* form a part of the plate and receive the ends of the hinge bolt for the console. The bolt is stationary and the tray revolves about it.

The console G supports the block upon the concave surface bounded by the guide rails *g*. The translating screw H has two threads cut in opposite directions, one,

right hand, which works in the thread in the tray, the other, left hand, which engages the translating stud a' of the block. On working the crank O the stud travels in an open way in the dish of the console over the screw, and the translating screw, whilst turning, also moves bodily to the rear, so that the motion of the block is equal to the pitch of the two threads combined. By this means the necessary travel of block is secured with a relatively short length of screw and console.

The latch L is automatic in opening and closing. When the block is withdrawn, the end of the translating screw will have moved back to clear the locking bolt *l*, when the ends of the grooves *a* in the block strike the ends of the guide rails *g* next the breech. The latch is then able to rotate against the resistance of the spring around *l*, and is thus rotated and released from its hook in the breech plate by the impetus of the block striking the ends of the guide rails, leaving the tray free to be swung to the right with continuous motion. In the closing movements, the latch catches as soon as the tray is swung back to the breech, and is completely locked when the translating screw moves forward.

The vent cover M is attached to the block and pivoted in a slot made to allow the necessary movement. When the block is turned for opening, the upper end of the cover is tripped by contact with the guide groove in the fixed breech plate, and the lower end is at once thrown over the vent, where it remains until the block is again locked ready for firing. When the block is withdrawn, the vent cover is in a vertical position, which it retains by gravity.

The two stud bolts R, with nuts, are fixtures on the block, provided for the attachment of a separate lever arm, to be used in turning the block in case of accident to the ordinary mechanism.

Views of types of this mechanism used on different classes of guns in the land service and on rapid-fire guns of the Navy are shown in Pl. VI.

Fig. 1 is a view of the 5-inch siege gun, having a mechanism similar to that of the 3.2-inch and 3.6-inch field guns and 7-inch howitzer. The block, gas check, and spindle are essentially the same as the 8-inch previously described, and an automatic vent cover is provided. The block is supported in a hinged carrier ring, through which it slides. It is turned by means of the folding lever, and, when closed and turned, is locked by lowering the lever handle, whereupon the eccentric head of the lever enters a beveled groove in the face of the carrier ring and prevents the block from unscrewing. The carrier ring has an automatic catch, arranged at the right-hand side. In closing the breech, this catch engages the ring as soon as the latter enters its seat in the breech and holds it fast whilst the block is being pushed in. Similarly the ring is held fast when the block is being withdrawn in opening the breech, and is not released until the block is withdrawn to the position shown with respect to the ring; the block then swings clear of the breech, by continuous movement.

Fig. 2 is a view of the 3.6-inch field mortar, having a mechanism similar to that of the 7-inch siege mortar, except that the gas check and spindle of the latter are like the corresponding parts of the 5-inch gun. The block and carrier ring of the field mortar are similar to the 5-inch gun. The handles of the block are fixed and the block is locked in the closed position by a sheared pin operated by the small handle at the rear. This pin is turned as a final motion, and in turning operates the

vent cover; it is fixed in the block and the unsheared part, when turned, engages in a groove in the carrier ring cut opposite its position when the block is closed and turned. The principle consists simply in locking a ring on a cylinder by inserting a pin in a hole made partly in each piece. The gas check is of the Freyre pattern, previously referred to, of which a section is shown in Fig. 5, Pl. VIII.

Fig. 3 is a view of the 12-inch seacoast gun, the mechanism of which is similar to the 8-inch, except that the threaded breech and block are divided into eight sectors instead of six, on account of the increase of caliber.

Figs. 5 and 6 are views of the Dashiell rapid-fire breech mechanism of 4-inch Navy gun, closed and open. All the operations of closing the block, or of opening it, and extracting the empty cartridge case, are performed in one motion by a continuous movement of the lever handle. The pivot-bolt of the operating lever passes through a hole in the elbow of the translating lever above and a curved slot in the console below, concentric with the pivot of the translating lever. The latter is a curved arm pivoted at one end to the console, and at the other end has an upturned hook engaged in an undercut on the rear face of the block. On moving the operating handle to open the breech, its pivot stands fast until the toothed segment at its base has moved the cross rack in the console to rotate the block and disengage the threads in the breech. On continuing the movement the center of motion is changed to the pivot of the translating lever and the end of this lever toward the block is rotated to the rear, drawing the block with it, whilst the pivot of the operating lever moves in the curved slot in the console. The automatic latch which holds the console to the breech is released when the block is fully out, and subsequent motion follows about the console hinge as a center. The block is guided whilst moving on the console, out or in, by the groove in the bottom, which slides upon a tooth of the rotating rack.

The Farcot mechanism is designed to effect a continuous movement, combined with sufficient power to operate heavy guns. The modified form of this mechanism, shown on Pl. VII, is designed for a 12-inch seacoast gun, to be worked by hand power. According to plans of this mechanism as used in the French navy, the pitch of thread on the pinion wheel A is 45 degrees, and the vertical shaft which carries this pinion is driven by machine power, the connection being made by a crank or friction pulley attached to the lower end of the shaft. And as an alternative for hand power the shaft is prolonged upward and its end squared to receive the eye of a long-handled rachet lever, the lever being removed when not in use. An important feature of the present modification, which is due to Lieut. Fletcher, U. S. Navy, consists in arranging the wheel A to work with a pitch of, say, 15 to 20 degrees, whereby the power required to rotate the block is so much reduced that hand power can be conveniently applied to operate the mechanism.

The block is shown in locked position in Fig. 1, and in the withdrawn position, at the point where the swing of the console begins, in the full lines of Fig. 2. The rack for operating the block is made in two parts, one a circular arm, B, at the rear of the block, and the other a straight arm, B′, laid longitudinally in a threaded sector of the block in a groove limited in width to the thickness of the wheel A. This groove is made sufficiently deep to lay the rack so that when the wheel A is traversing this arm it will be constrained by the sides of the groove to impart a motion of translation only to the block. The gearing on the two arms of the rack is made continuous to fit with the wheel A. Starting with the closed position, the operation of opening the breech by continuous movement of the crank is as follows: The motion of the crank is communicated through its shaft and worm to the wheel C, which, together with A, is fixed to the vertical shaft and revolves with it. At first the wheel A, engaging in the circular arm of the rack B, will rotate the block to the left until the rotation is stopped by the shoulder *a* of the block coming in contact with the guide rail *g* of the console. In this operation, which is the one requiring the greatest power in the series, the wheel A acts as a worm; hence the advantage of the slight pitch of the teeth on that wheel. Then, the block being no longer able to turn, the wheel A, continuing to engage in the teeth of the rack, will force the block outward in traversing the long arm of the rack. When the block, traveling on the guides of the console, is fully out, it will trip the latch of the console and release its hold on the breech, as previously described for the 8-inch breech mechanism. The console carrying the block is then free to revolve about the vertical shaft, and will be moved to the open position shown in the dotted lines, Fig. 2, being carried around by the wheel A, the teeth of which still remain engaged in the rack. A reversal of the motions for opening will cause the block to be closed and locked by continuous movements. The longitudinal grooves in the bottom of the block, sliding over the guide rails of the console, restrain the block from rotating whilst moving on the console, and prevent undue friction of the wheel A upon the side of its traveling groove toward which it tends to work—lower when the block is moving out and upper when it is moving in. It may be seen that the worm of the crank shaft will lock the block in the closed position, or hold it in any position within the scope of the movements of the mechanism. Anti-friction bearings, *c*, are provided, two on the crank shaft to reduce the friction from the thrust of that shaft in either direction and one under the hub of the console to reduce the friction from the weight of the console and block, more particularly in case it is desired to load with the gun elevated, so that it need not always be brought to the horizontal position for loading.

THE SLIDING-WEDGE SYSTEM.

In the Krupp guns the breech is formed by the jacket piece, which projects singly to the rear, and is bored through in prolongation of the axis of the bore to afford a passage for loading at the rear. The opening for the block is a slot cut horizontally through both sides of the projecting jacket and intersecting the prolongation of the bore immediately in rear of the powder chamber. When the block is closed its front face closes the rear of the powder chamber and forms the bottom of the bore. The wedge shape of the block and opening permits lateral freedom of movement except when the block is closed. The following description of an 8-inch breech mechanism made on this system, although not of recent date and differing probably in some details from present practices, will suffice to explain the general features of the system. (See Figs. 1 and 2, Pl. VIII.)

The steel breechblock E is constructed on the sliding-wedge system and is cylindro-prismatic in form. The front face of the block is perpendicular to the axis of the bore, while the rear or cylindrical portion is inclined 1° 15′. The movement is regulated by the two guides *g g* in the slot, which work in corresponding grooves in the block, and are constructed parallel to the axis of its cylindrical portion.

The front of the block is hollowed out for the reception of a hardened disk *c* called the obturator plate. This plate, when the breech is closed, abuts against the gas check *f*, which consists of a Broadwell ring inserted in a recess at the rear of the tube.

The breechblock is fitted to receive the different pieces of mechanism required for working it. These consist of the locking plate *a*, the translating screw *b*, and the locking screw *c′*, with its nut *d*. The locking plate is attached by screws to the left side of the breechblock. The translating screw is located in a longitudinal groove in the upper surface of the block, and is secured in position by bearings at each end. It works in the half nut *e*, which is attached to the breech receiver by a screw.

The locking screw and its nut are located in a cylindrical recess at the rear of the block and next to the locking plate. The neck of the screw passes through and turns in a hole in the locking plate and the opposite end in a recess in the breechblock. The nut is made about one-half an inch shorter than the recess, which allows it a motion of translation along the screw for that distance. At the end of the nut next to the locking plate is attached a stud, which limits its rotary motion with the screw to one third of a turn. On the interior surface of the nut are four rings or circular threads; the one next to the locking plate is complete, while the others are partially sheared off. When the breech is nearly closed the sheared threads lock into the indentations *g′* and the complete one enters the recess *f′*. In withdrawing the block the sheared portion of the nut is brought to the rear.

The two screws are worked in turn by the lever wrench C.

To close the breech the wrench is placed upon the head of the translating screw and the block run in until the uncut thread of the locking nut comes to a bearing in its recess and brings the movement to a stop. The wrench is then shifted to the locking screw; for one-third of a turn the screw and nut turn together, and the partially sheared threads of the nut lock into their corresponding recesses on the breech receiver. The movement of the nut is then stopped by its stud while the movement of the screw continues, and bringing the threads of the nut to a firm bearing on the faces of their recesses on the breech receiver forces

the block into the slot until it is firmly wedged and the breech thus fully closed.

To open the breech the locking screw is turned in the opposite direction, and by carrying the nut with it for one-third of a turn the unlocking is effected. The nut is brought to a stop by the stud as before, the uncut thread comes to a bearing against the face of its recess, and the block is drawn out until the nut is reached by the end of the screw. The remainder of the movement is then effected by the translating screw.

The alternate form of gas check shown in Fig. 3, having a deep groove around the outside of the ring, is stated to be one of the best devised in this system for preventing the escape of gas through the joint between the ring and its seat in the powder chamber. The second joint through which the gas may escape is that between the base of the ring and the face of the obturator plate where the ring rests upon the plate. The grooves in the base of the ring assist in preventing the escape of gas through this joint, and an adjustment of the position of the obturator plate to maintain a close joint is made by inserting thin strips of metal behind the plate to raise it slightly as required. The safety device against premature discharge can be arranged in this system by having the vent channel pass through the wall of the jacket and the breech-block so that the channel is cut off by the surface of the block except when the latter is closed.

Examples of the sliding-wedge system are found in the Hotchkiss and Gruson rapid-fire guns, where, however, the block having a flat, wedge-shaped back is set vertically instead of horizontally, and is moved downwards by a rapid lever motion in opening. The cartridge cases used with the fixed ammunition in these guns constitute the gas check.

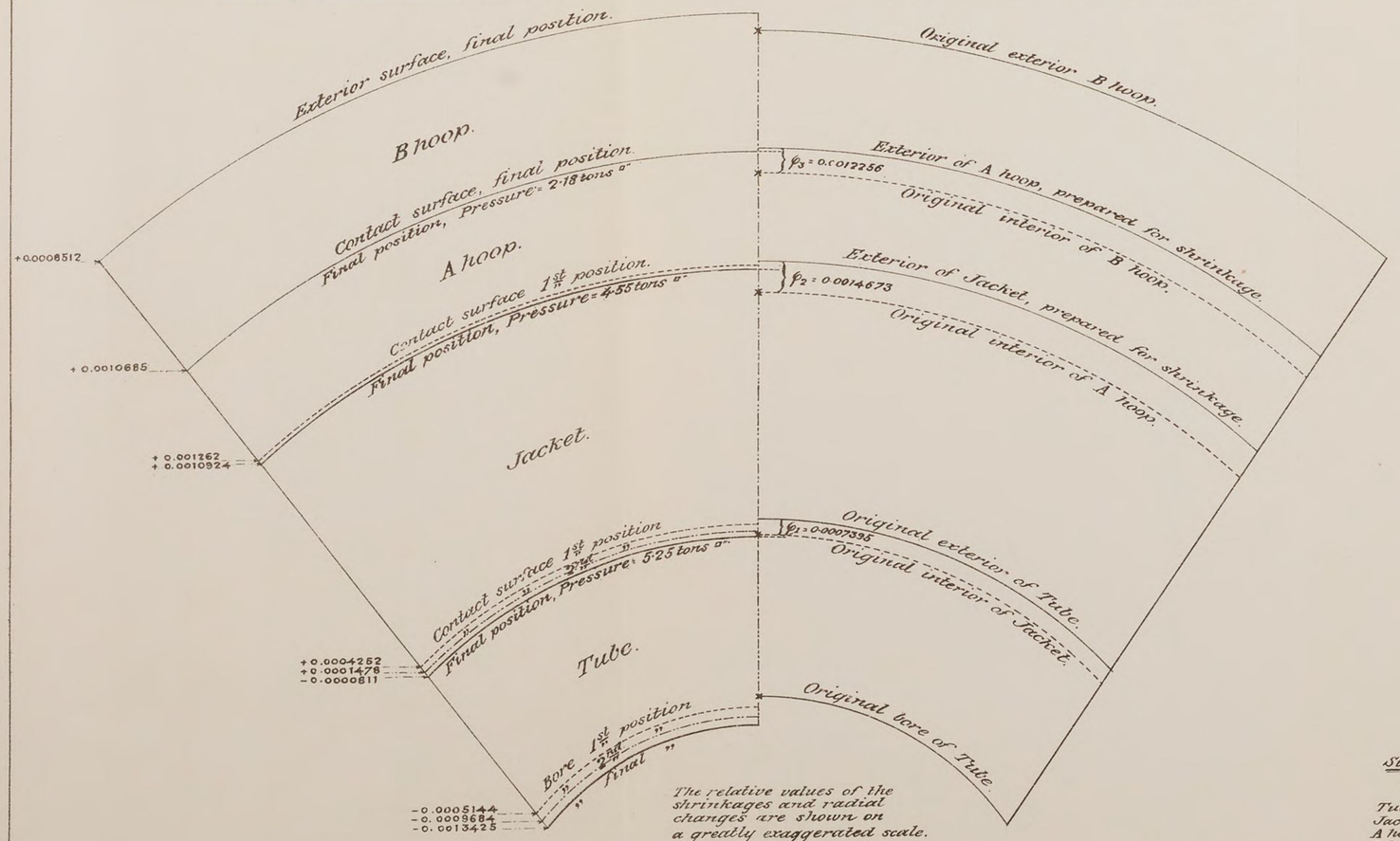
Both the screw and the sliding-wedge systems have been well developed and extensively applied and tested in gun construction; it, therefore, need scarcely be said that no fatal defect can be pointed out in either of them, and their long-continued supremacy indicates how difficult it may be to devise a better plan. The wedge is the simpler of the two. It is less liable than the screw to become stuck, and, moreover, on account of its position, the block may be more easily removed by extraneous means if required, in a case of sticking, which might otherwise temporarily disable the gun. It, however, requires a much heavier jacket forging to afford the same longitudinal strength as the screw, thereby increasing the difficulty of securing good metal in this forging and is less effective in sealing the escape of the powder gases.

Aside from the form of gas check to which the system is limited the pull of the block is not uniformly distributed over the cross section of the jacket, and there is a tendency to render the seat for the gas check oval in form with the longer axis parallel to that of the slot. Other apparent advantages of the screw over the wedge system are that the

breech mechanism is somewhat less exposed to fire from the front, and less care need be exercised in loading, since the closing of the block from the rear will push forward a partly-inserted charge, which, on the other hand, would be caught by the cross motion of the sliding block. A further advantage of the screw is that it permits a reduction of the total length for a gun of equal power in the two systems, and thus economizes space for the installation of the gun where emplacements of limited extent are to be used, as in casemates, turrets, and ships. The breech mechanism and its adjuncts occupy a shorter portion of the total length of gun and hence give a greater effective length as measured from the bottom of the bore to the muzzle. This increase of effective length varies from one-half to one caliber of the gun in various constructions. Consequently, for a given caliber and total length, the screw system will produce a more powerful gun than the sliding wedge or it will produce a gun of equal power with shorter length. This saving of length may be accompanied by some reduction also in the total weight of metal, for although the greater diameter of breech over the screw may nearly offset the weight contained in the longer and smaller breech in the heavier guns of the Krupp system, yet the breech band which is applied over the rear of the powder chamber in the latter system makes it possible to adjust the balance of weight upon the whole in favor of the screw system.

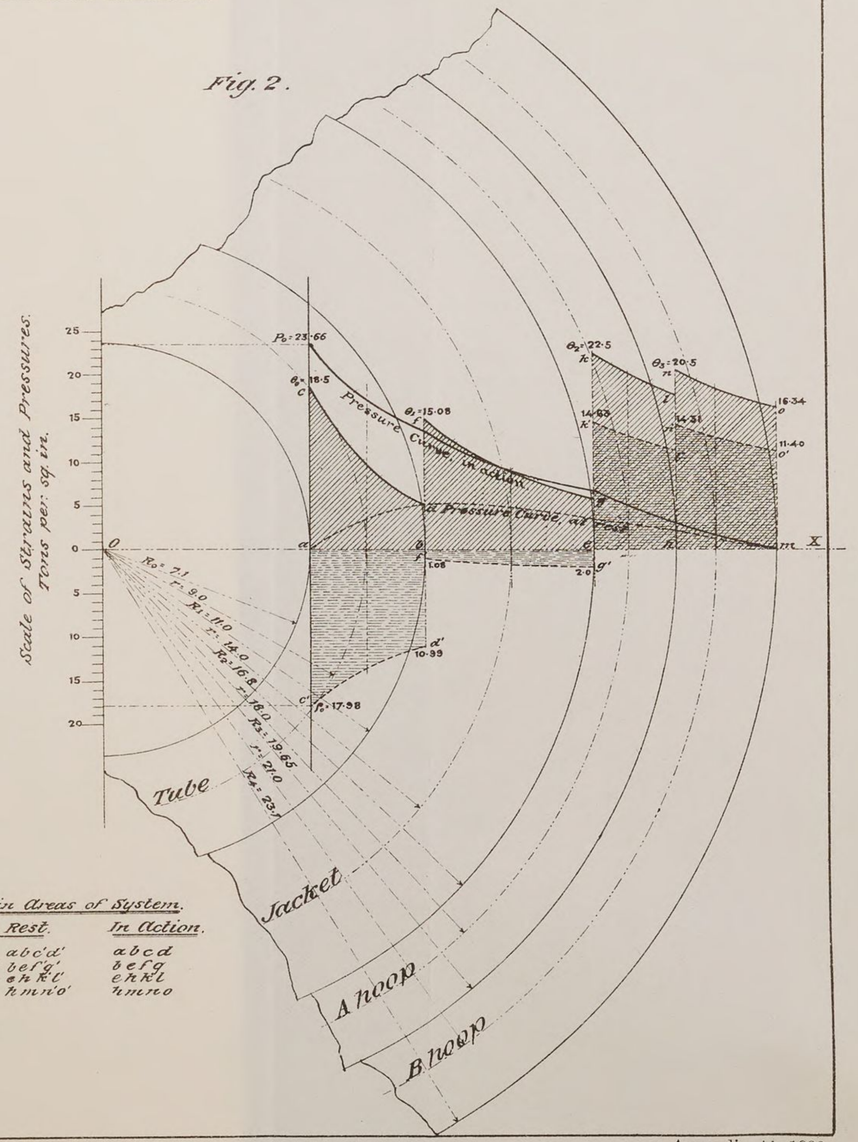
Shrinkage, Pressures and Strains, Section of Powder Chamber.
12in B. L. Rifle, Steel.

Stages of the Assemblage — Fig. 1. — Parts prepared for Assemblage



The relative values of the shrinkages and radial changes are shown on a greatly exaggerated scale.

Fig. 2.



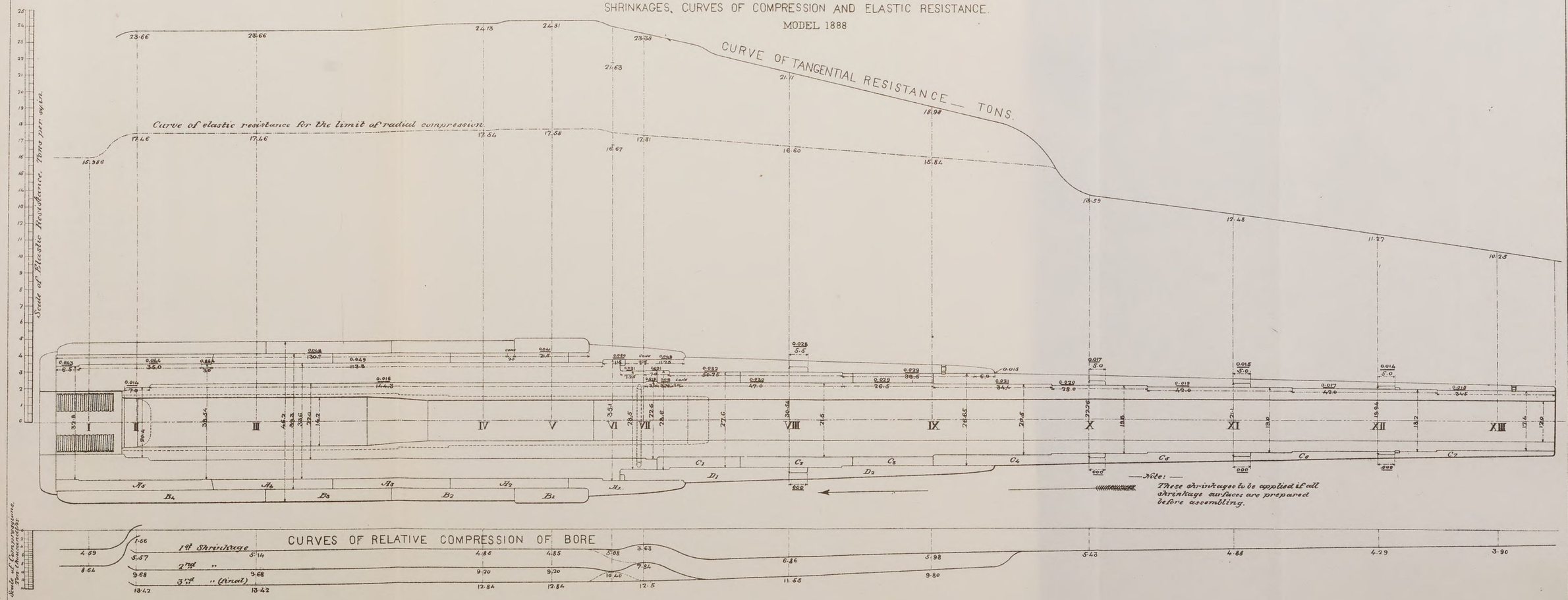
Strain Areas of System.

	At Rest.	In Action.
Tube	a b c' d'	a b c d
Jacket	b e' f' g'	b e f g
A hoop	e h K' l'	e h K l
B hoop	h m n o'	h m n o

12 INCH B.L.RIFLE.— STEEL. 52 TONS.

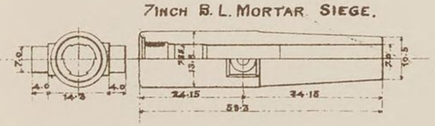
SHRINKAGES, CURVES OF COMPRESSION AND ELASTIC RESISTANCE.

MODEL 1888

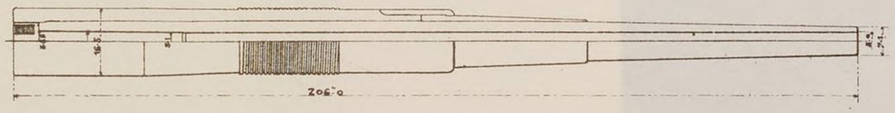


3·2 INCH B. L. STEEL, FIELD RIFLE

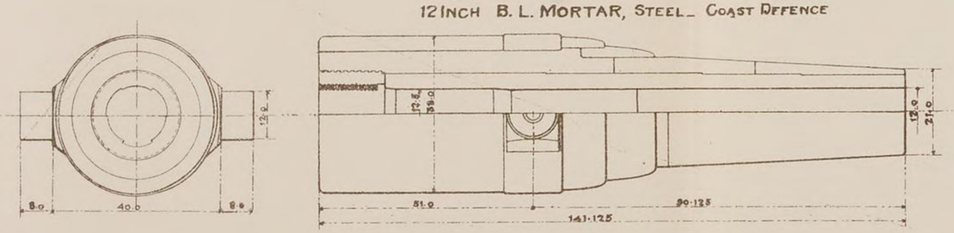
7INCH B. L. MORTAR SIEGE.



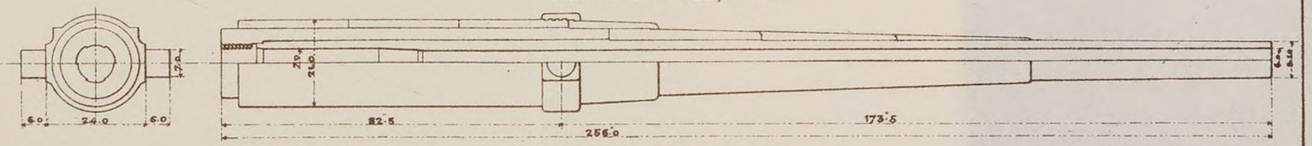
5INCH. R. F. GUN. NAVY.



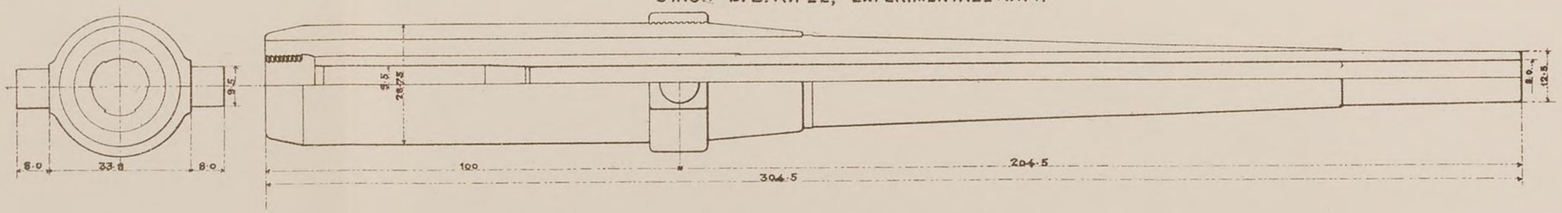
12INCH B. L. MORTAR, STEEL_ COAST DEFENCE



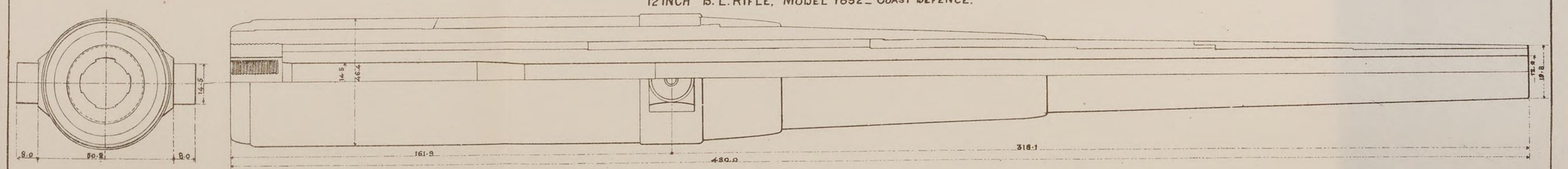
6INCH. B. L. RIFLE, NAVY



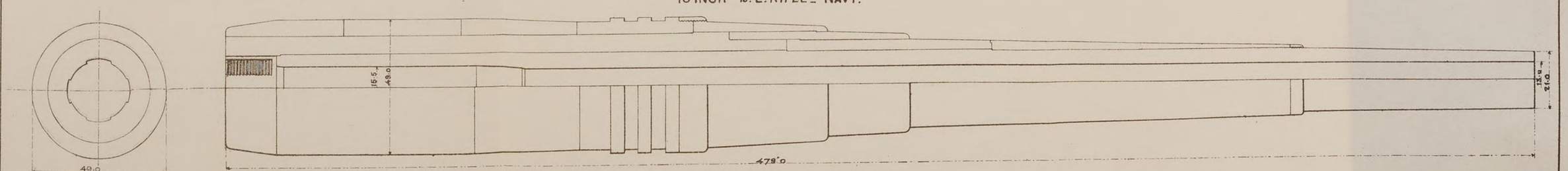
8INCH B. L. RIFLE, EXPERIMENTAL_ NAVY.



12INCH B. L. RIFLE, MODEL 1892_ COAST DEFENCE.

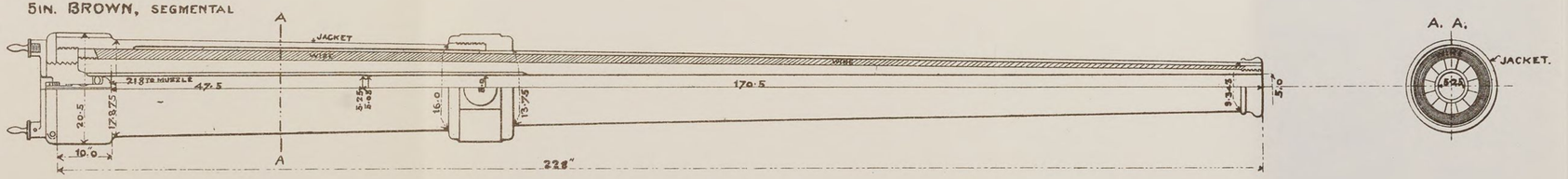


13INCH B. L. RIFLE_ NAVY.

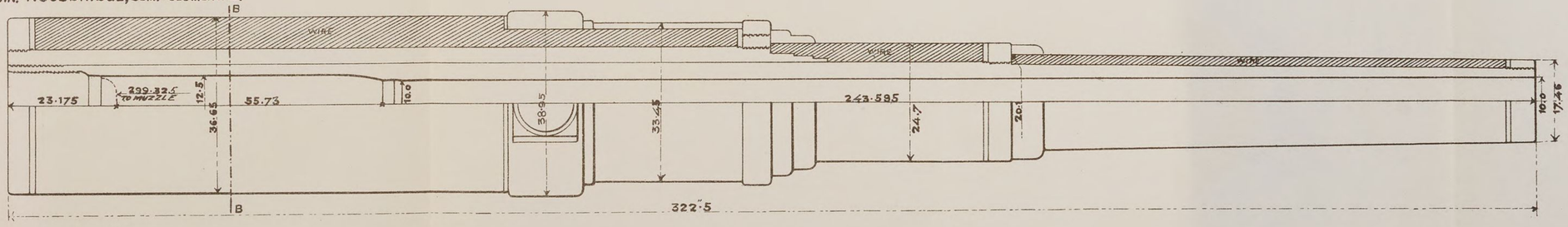


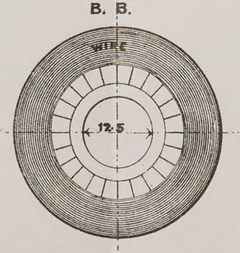
EXPERIMENTAL WIRE-WOUND GUNS

5IN. BROWN, SEGMENTAL

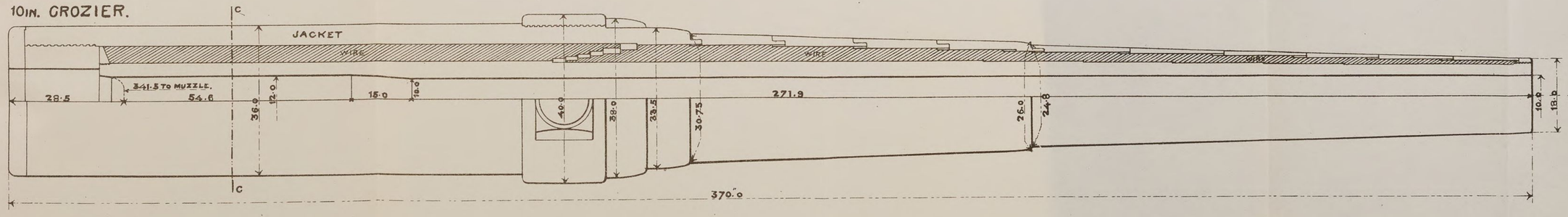


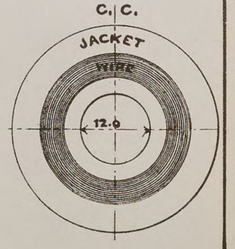
10IN. WOODBRIDGE, SEMI-SEGMENTAL.





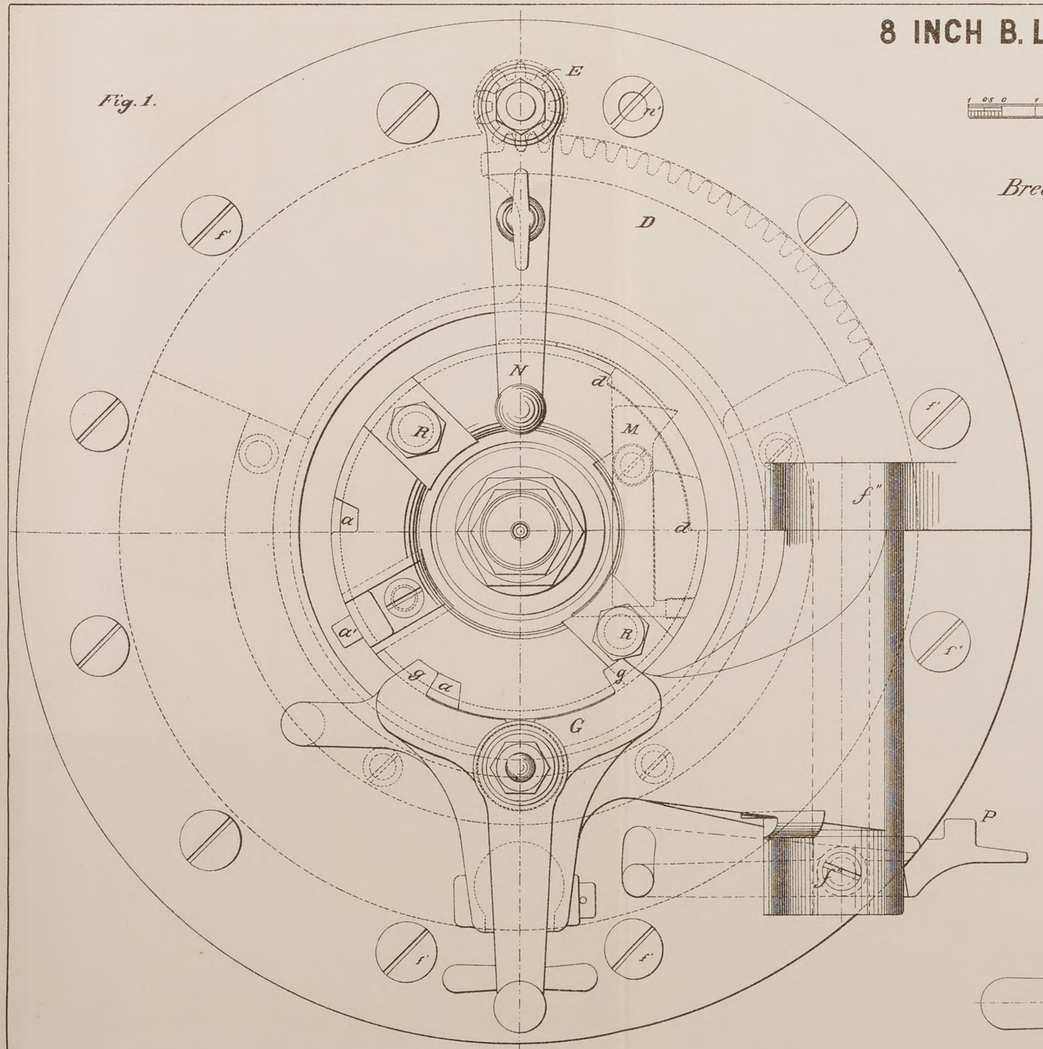
10IN. CROZIER.





8 INCH B. L. RIFLE.— STEEL, 14½ TONS.

Fig. 1.



0 0.5 1 2 3 4 5 6 7 8 9 10 inches.

Breech locked, ready for firing.

Fig 2.

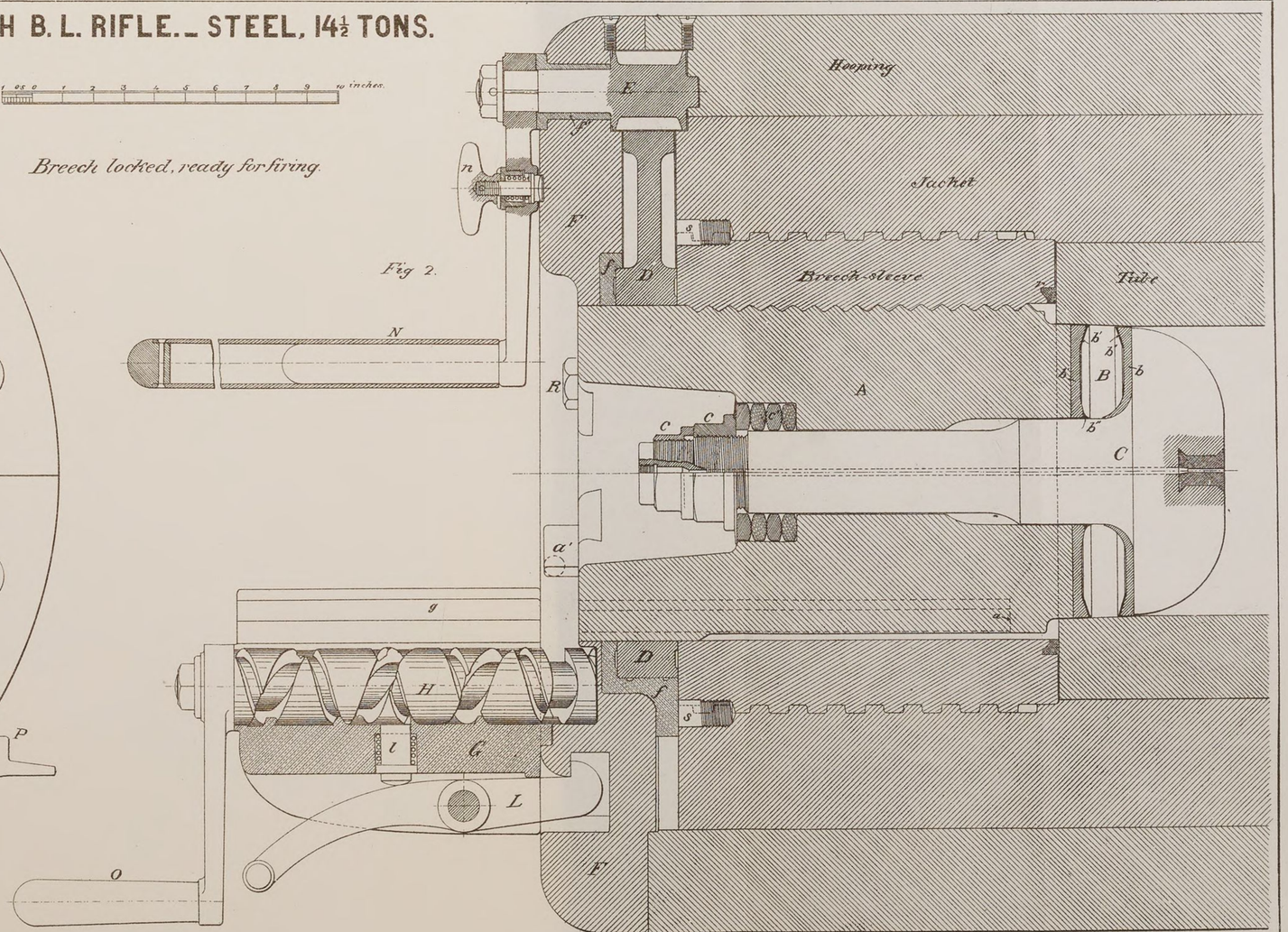


FIG. 1. 5″ siege.

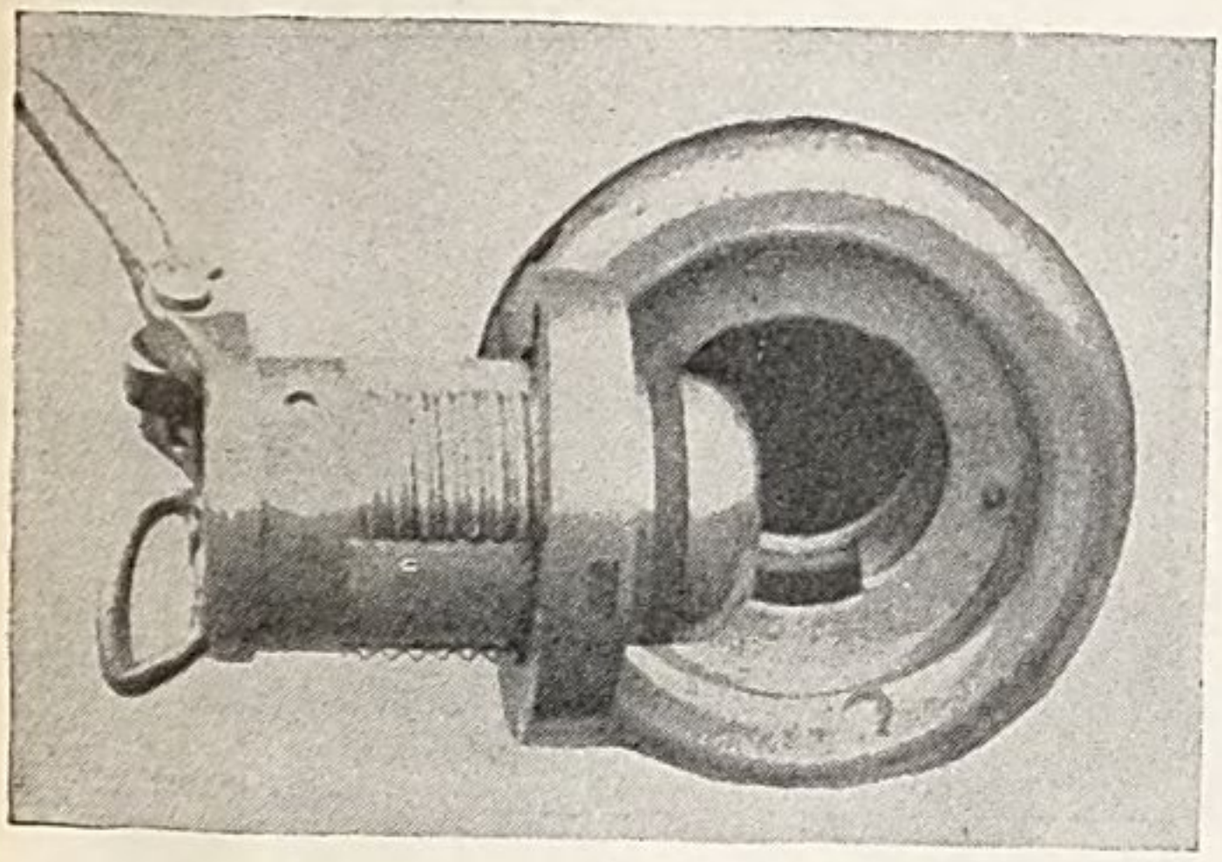


FIG. 2. 3.6″ mortar.

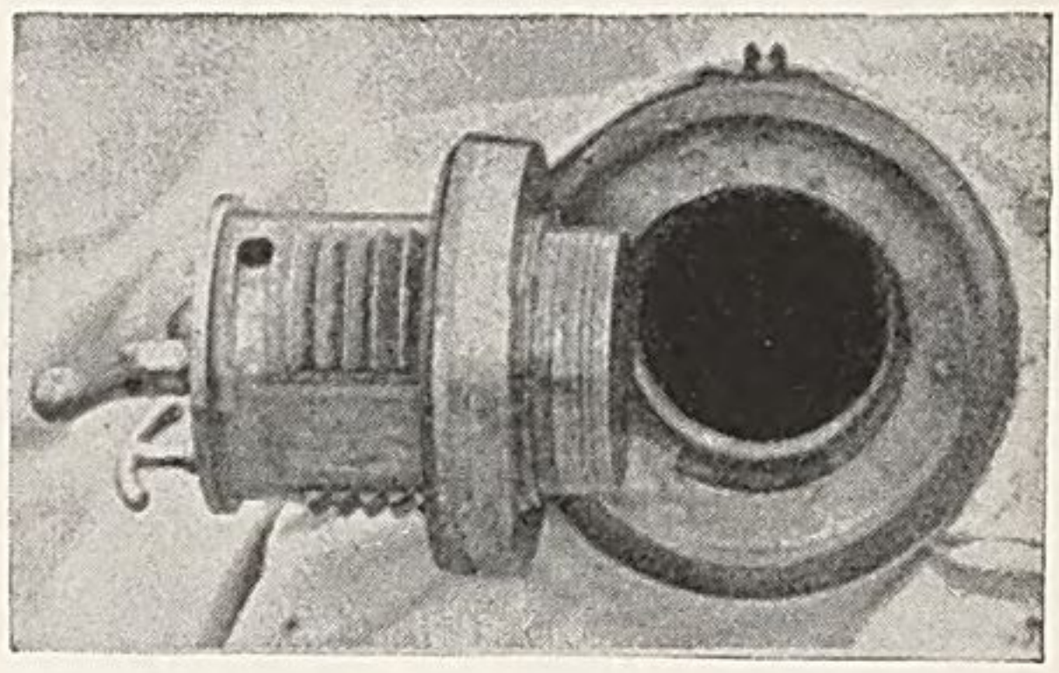


FIG. 3.

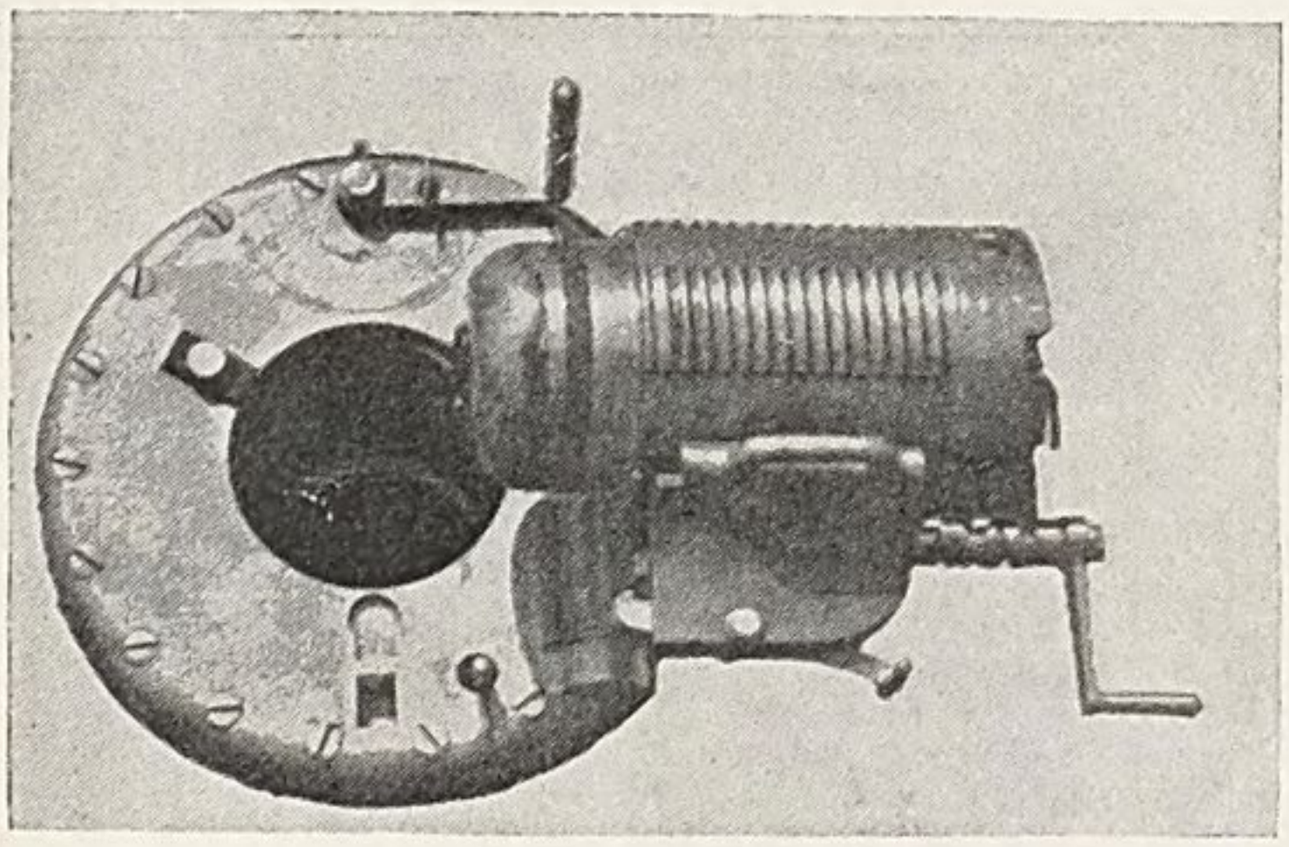


FIG. 5.

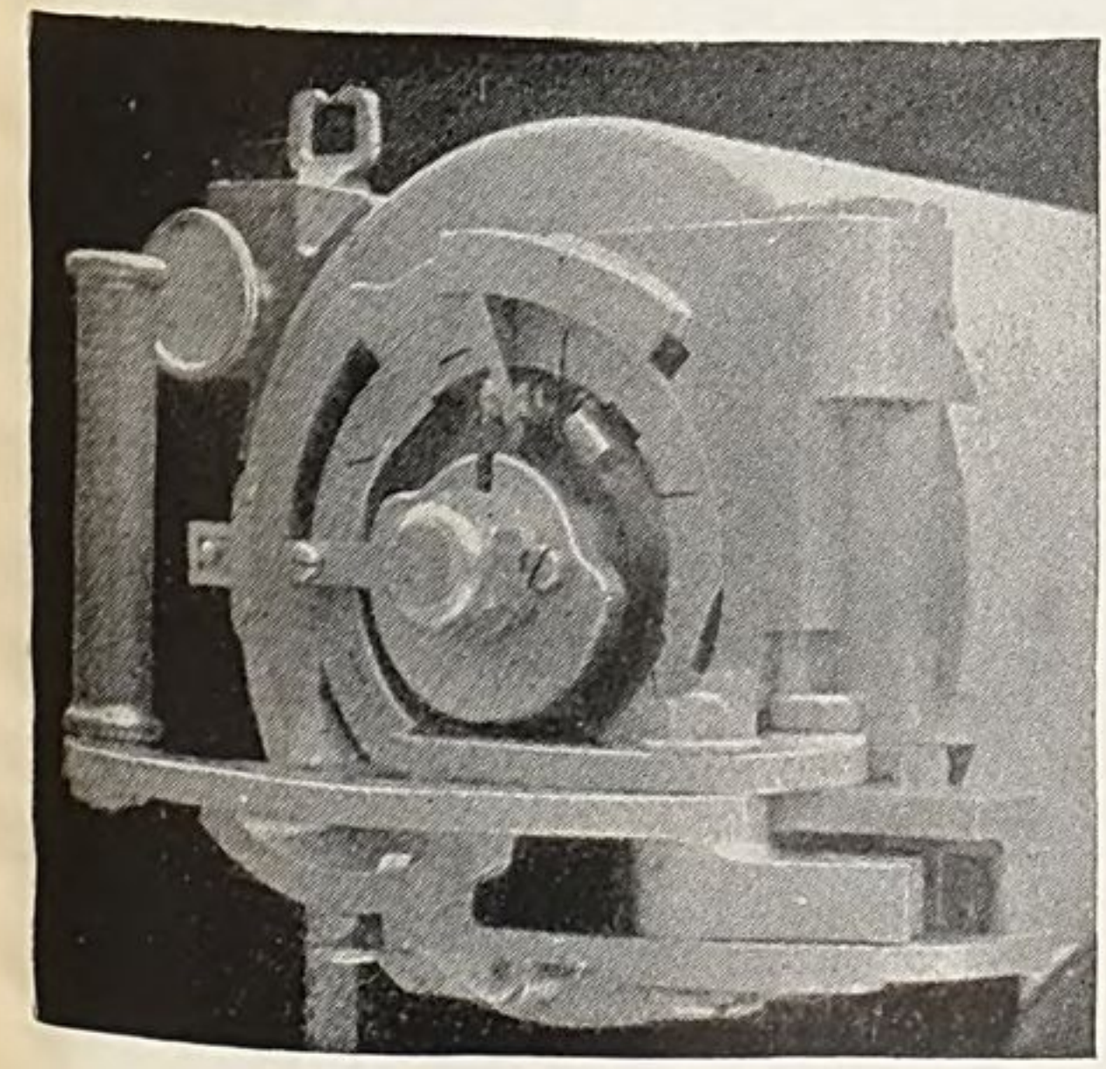
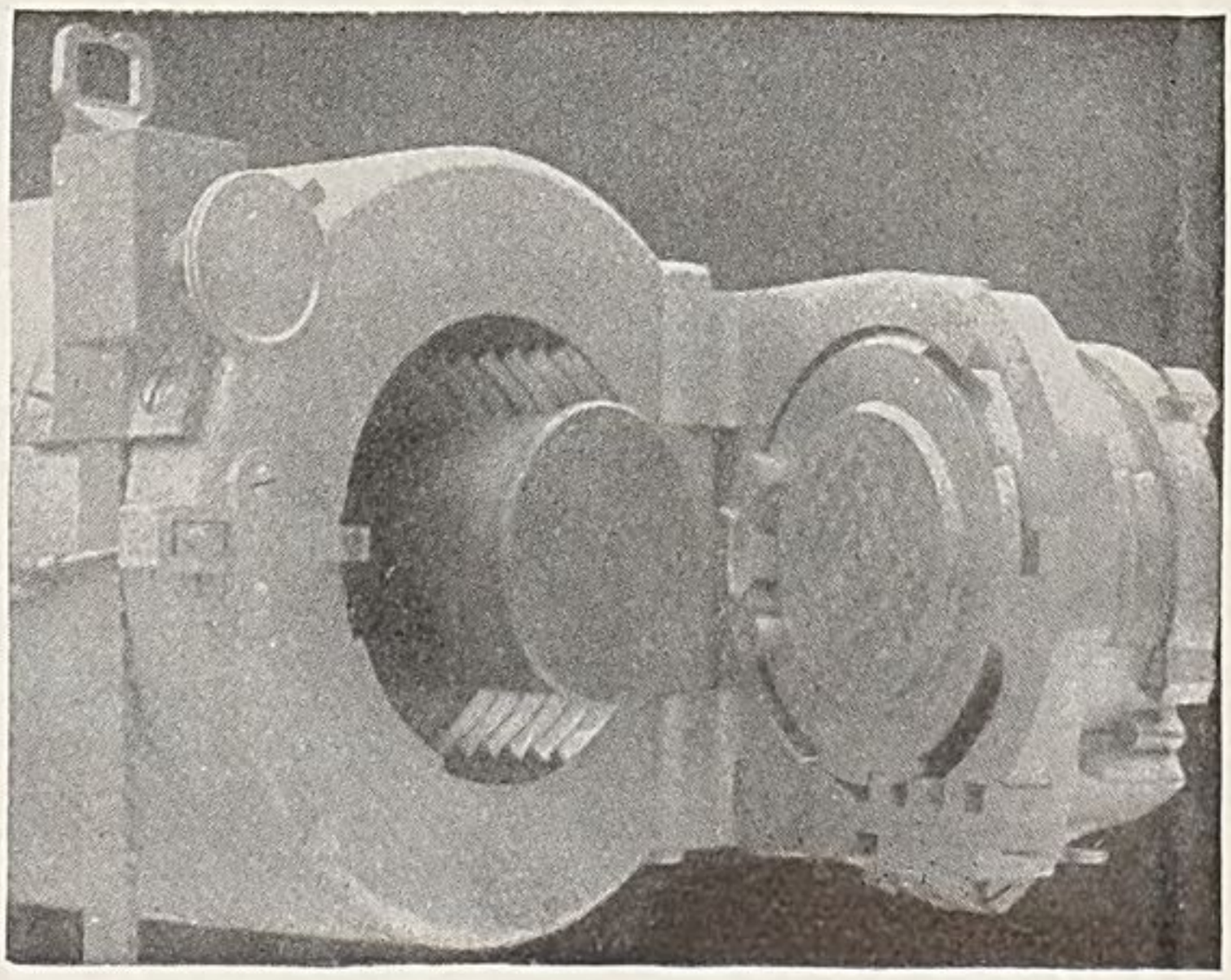


FIG. 6.



FARCOT' BREECH MECHANISM, MODIFIED.

FOR

12 IN. B. L. RIFLE

Fig. 1.

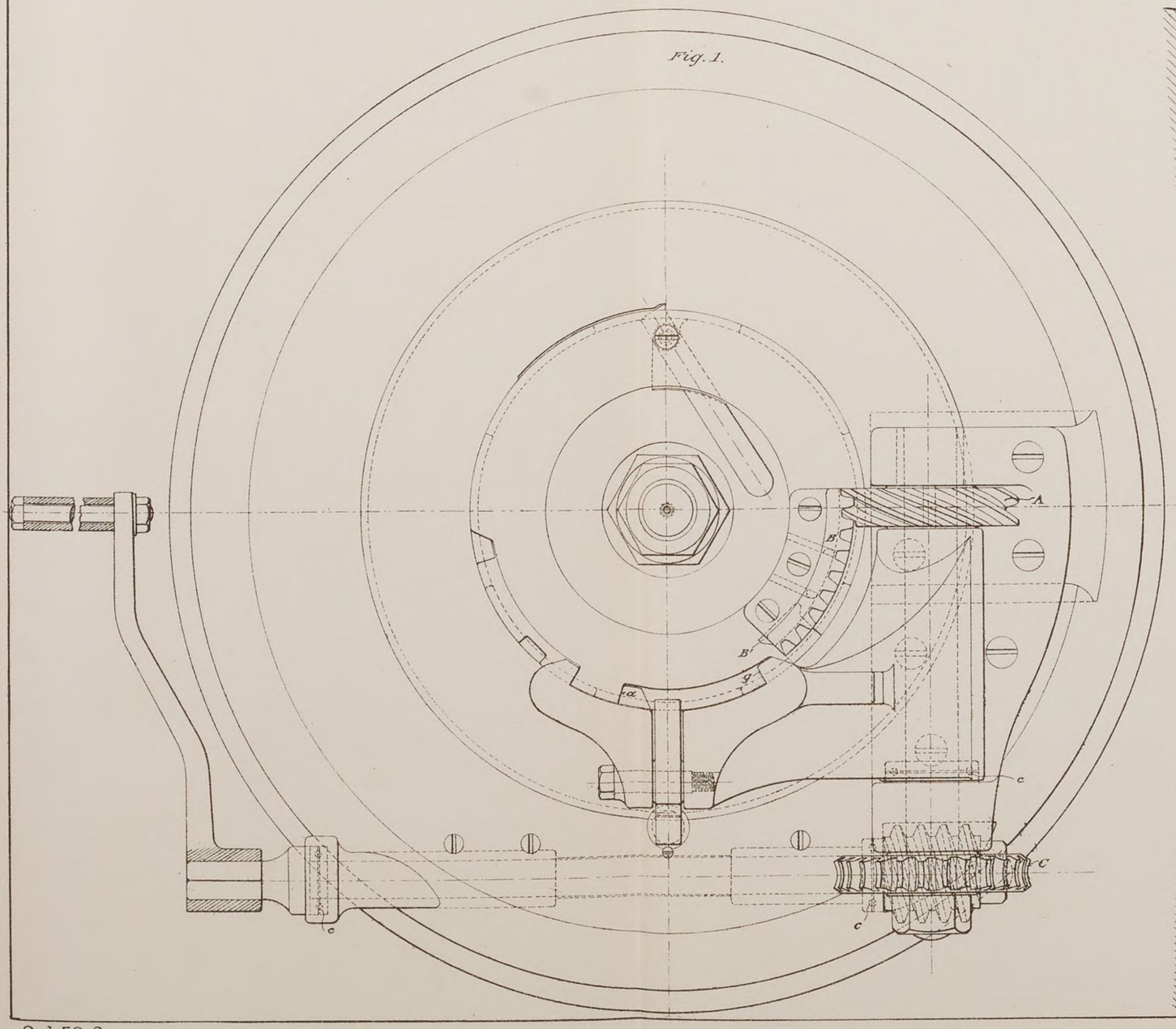
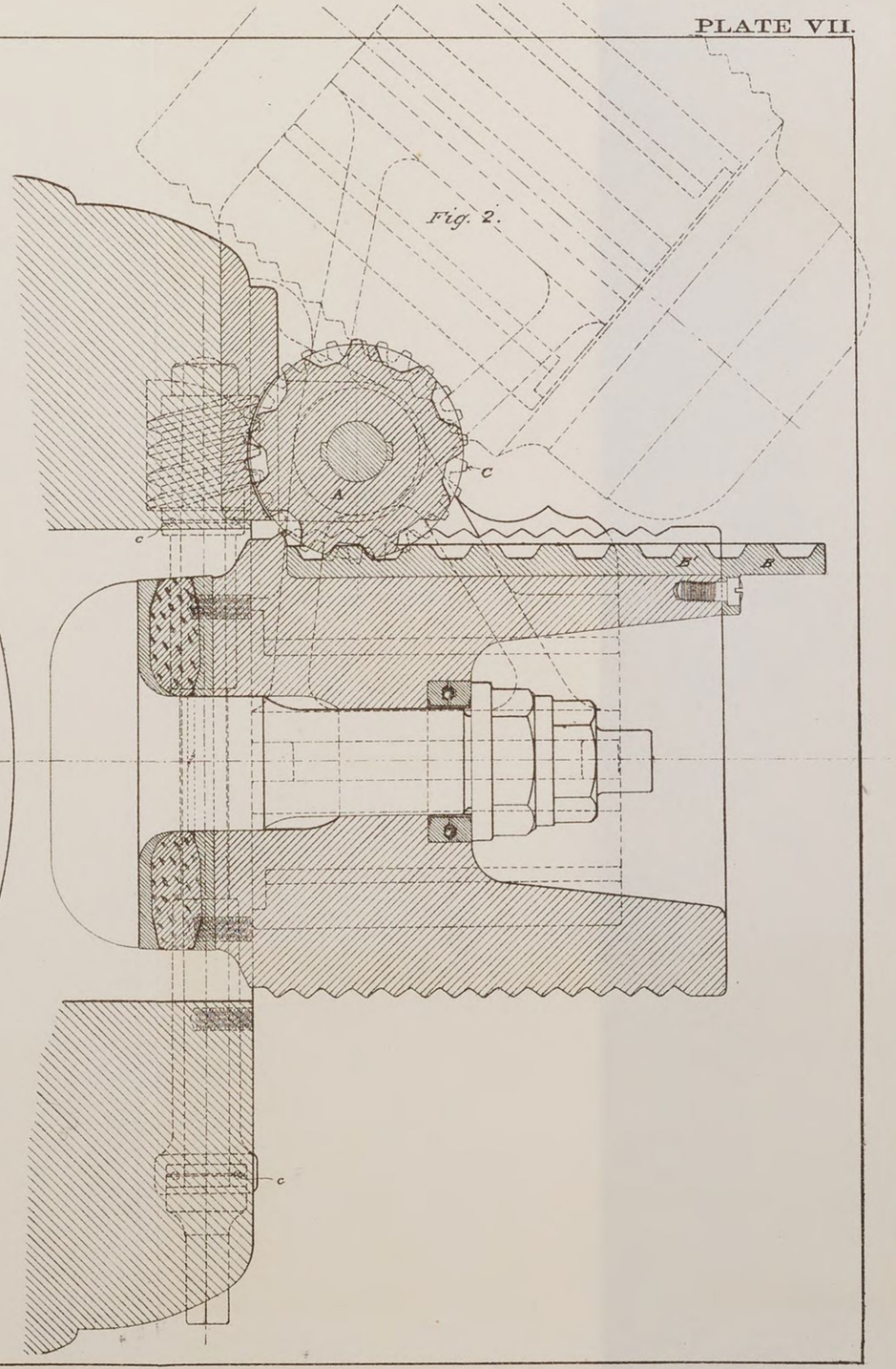


Fig. 2.



KRUPP BREECH MECHANISM
8IN. RIFLE.

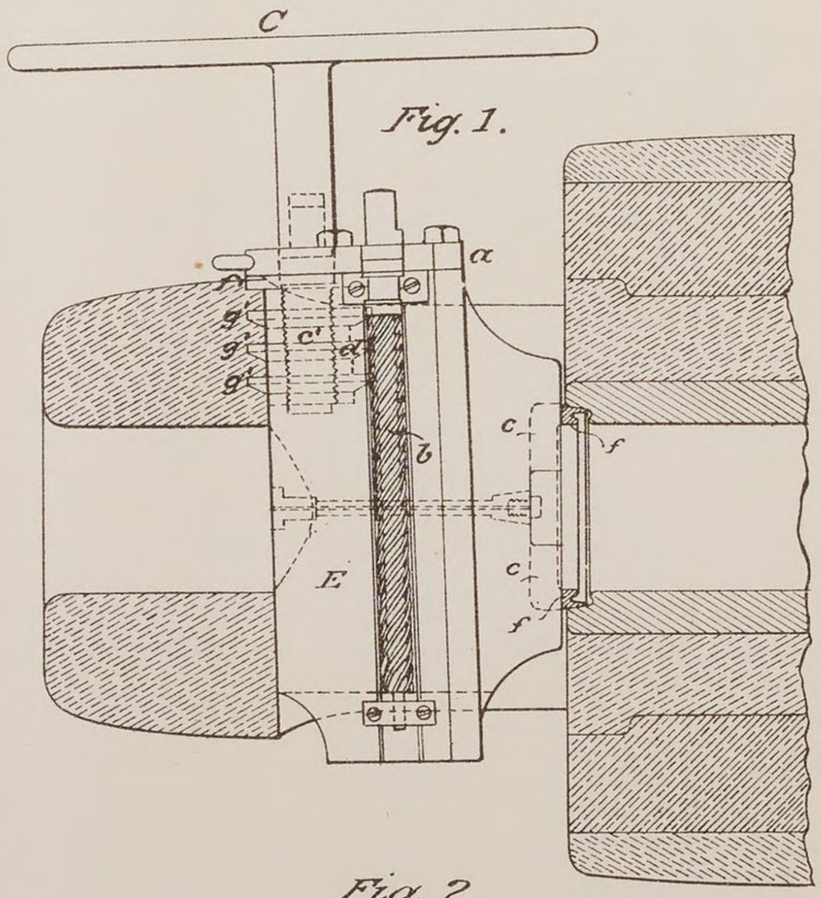


Fig. 1.

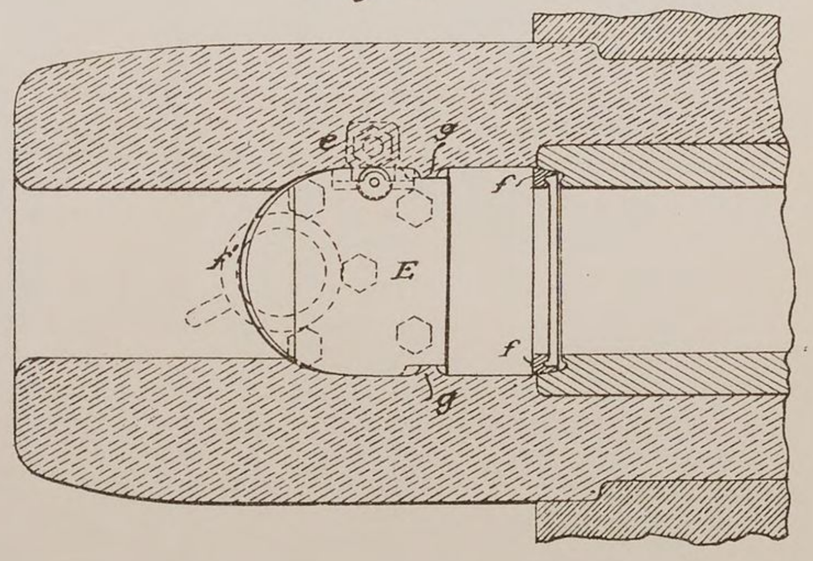


Fig. 2.

KRUPP GAS CHECK
MODIFIED

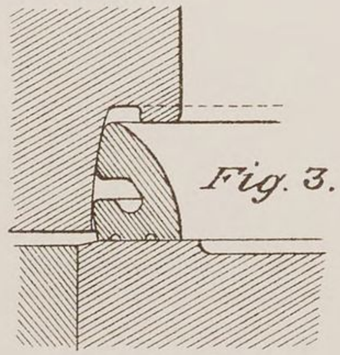


Fig. 3.

ITALIAN GAS CHECK

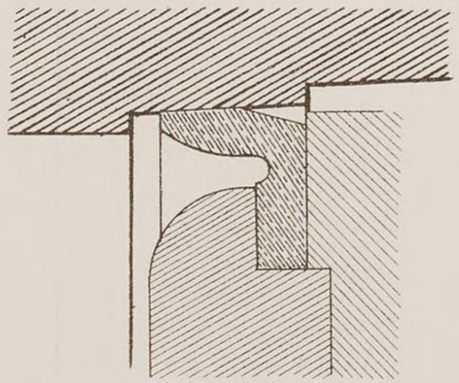
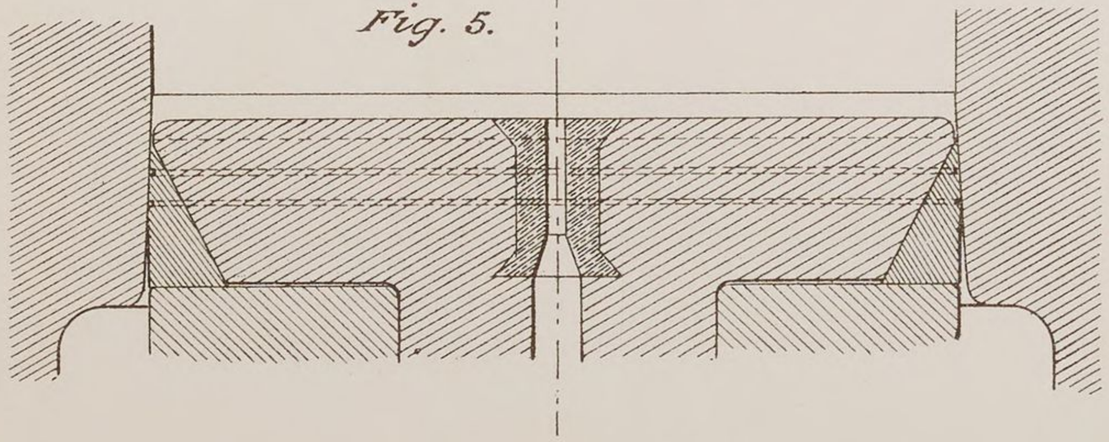


Fig. 4.

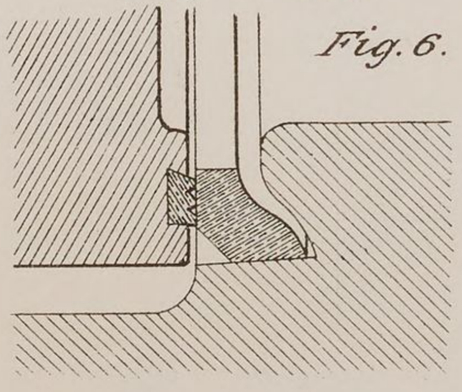
FREYRE GAS CHECK

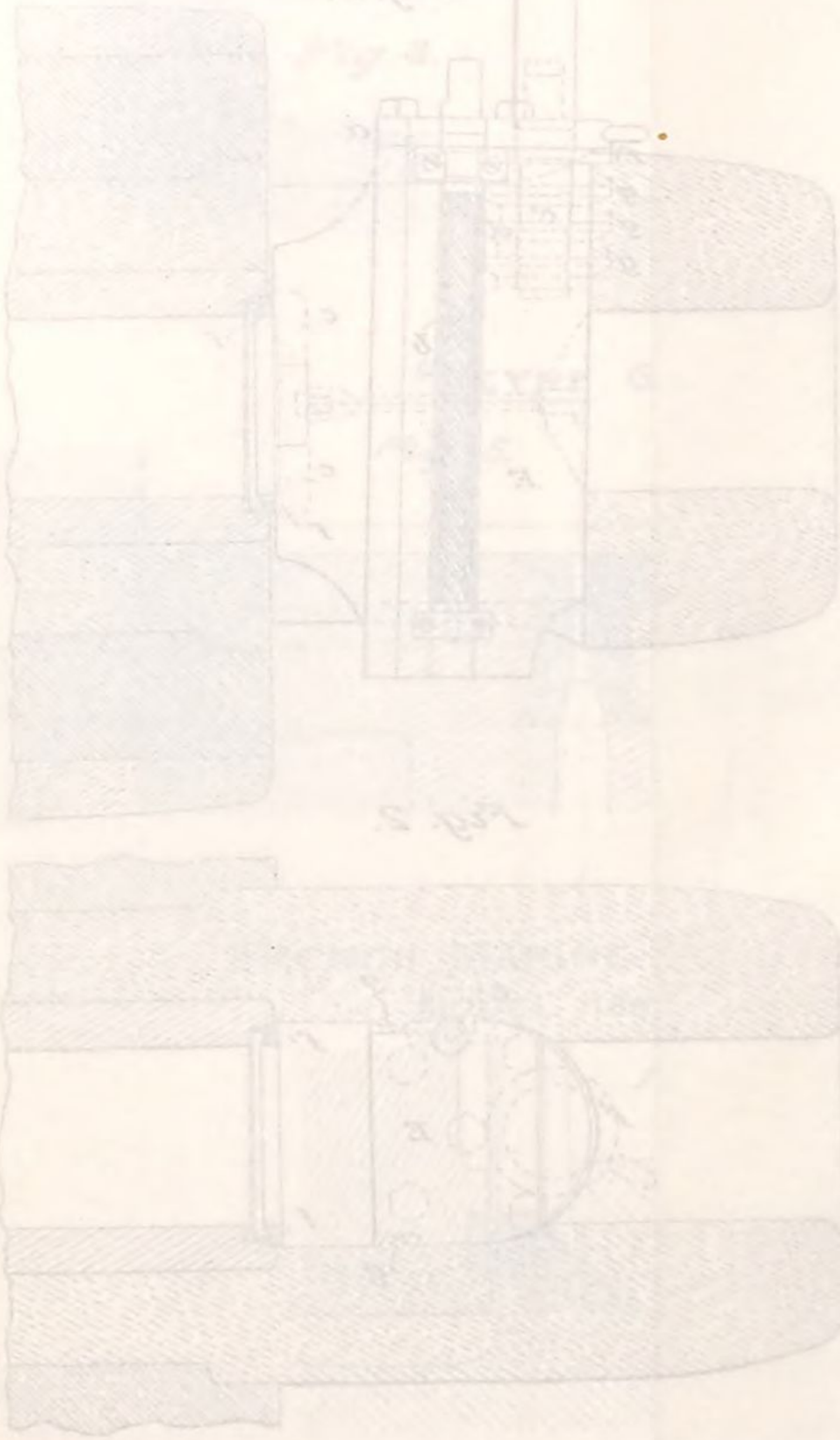
Fig. 5.



FRENCH MARINE GAS CHECK
MODEL 1884

Fig. 6.





APPENDIX 45.

DISAPPEARING GUN-CARRIAGES. BY CAPT. W. B. GORDON, ORDNANCE DEPARTMENT, U. S. ARMY.

(13 plates.)

There are many considerations which make the study of disappearing carriages one of the most interesting in modern artiilery development. The high power of the best artillery of to-day has been obtained only after infinite labor and the expenditure of enormous sums of money, and there is still an evident tendency toward a further increase in both individual power and rapidity of fire. In this development the tendency is toward medium calibers and high velocities, and this tendency is naturally more marked in naval artillery than in land defenses. The small caliber infantry rifle is a progress in the same direction, but small-arm development is of course much more rapid and easy than any radical changes in heavy cannon. Considering the great difficulties in the way of producing a very effective armament of the largest calibers, it seems strange that the small arm has been the leader in this direction when no corresponding difficulty existed with the old infantry rifle. However, it is possible that a slow initiative toward lower calibers and higher velocities in artillery was the cue for a later and more rapid progress of the small arm in the same direction.

A very considerable increase in power has been obtained by the use of smokeless powders in guns designed for the brown powders, but the most effective use of smokeless powder undoubtedly involves new gun designs of greater length and chamber capacity. Fortunately the progress in the manufacture of steel, and the emergence of gun making from the domain of mystery, make any reasonable advance wholly a question of time and money.

With every increase in power the carriage problem has become more difficult, and until recently the carriage has not kept pace with the gun. But the progress made in the last few years indicates that for permanent emplacements this disparity in development no longer exists. When mobility is one of the most important considerations it can scarcely be said that the problem has yet been satisfactorily solved.

It is believed that no great difficulty will be encountered in designing carriages for guns of any power for use in permanent fortifications.

Certain types of barbette carriages are now used with entire success, and any increase in the power of artillery may readily be met by simple modifications in the details of construction.

With disappearing carriages the question is mainly a matter of cost, experiments showing conclusively that the disappearing principle may be successfully applied in various ways. Comparisons will of course be made as to relative cost, cover, simplicity of construction and liability to derangement, facility of handling, ease of maneuvering by hand, and rapidity of fire. A nice adjustment of all these elements may be necessary in drawing conclusions as to the different designs which have been proposed, but in the variety of sites to be defended it is not improbable that advantageous use may be made of all designs which prove to be successful under test.

But the question of relative cost of carriage and emplacement must be considered in connection with the cost of fortification. An increased expense in one direction is of course justified by a greater saving in another, provided efficiency be not sacrificed.

All positions in which barbette guns would run much risk of being disabled should be provided with some form of disappearing carriage.

There is necessarily a large element of conjecture in selecting conditions which involve new appliances in warfare, simply because the experience of battle can come only after the selection has been made. In the proposed use of disappearing carriages the element which is generally most prominent is *cover in its relation to the defense.* The propriety of this prominence is not questioned, but it is feared that it may sometimes obscure the very important question of *cover in its relation to the attack.* These two questions are quite distinct, though related to each other, and both work to the advantage of the defense. The moral effect on the attack of hidden batteries in the defense must bear a very intimate relation to the degree of cover, and when complete cover *from view* is practicable but little preparation need be made to resist penetration. A fleet can not carry a sufficient supply of ammunition to silence batteries which are practically or completely out of sight, and against a properly organized defense of this character a direct attack would be hopeless.

The question of economy in actual war can receive but little consideration, but in the preparation for war this question is always one of the most prominent in the art of fortification and defense. When appropriations are comparatively meager it is of the utmost importance to reduce the fortifications to a minimum and to mount the maximum number of guns. In solving this problem the conditions must of course be made to give the largest possible volume of deliberate aimed fire on all of the approaches. This as a general principle is evident, but no doubt much difference of opinion may exist as to the conditions necessary to secure the desired result.

Covered batteries in very much exposed works are still targets, and

they may be attacked with some hope of success. Hence it would seem to be desirable to screen batteries when this can possibly be done. With a given expenditure the defense can thus be made more efficient, and for emergencies a defense can be organized in a comparatively short time.

A gun mounted so as to form a good target should be very well protected, even though it be under cover except when firing. But where an extensive site affords ample opportunity to widely separate the guns of the defense, too much importance can not be attached to the fact that if a gun can not be seen long enough to get its direction and range it will generally need no other defense. Compact batteries consisting of many guns afford many chances of being hit, and hence the cover provided should have sufficient strength to resist penetration. But the disappearing carriage is reasonably safe if it can be properly hidden. The question therefore arises as to dispensing with costly fortifications for certain sites and mounting guns on disappearing carriages whereon they can be served effectively and at the same time be so concealed as to practically present no target for the attack. The amount thus saved by inexpensive emplacements could be used to increase the number of guns.

Some interesting experiments were made in England a few years ago for the purpose of testing the efficiency of such a system. A pit was made in an open grass field, and a dummy 10-inch rifle 36 calibers in length, made of wood, was mounted so as to appear and disappear at regular intervals, a puff of smoke preceding each disappearance. The dummy thus mounted was used as a target for H. M. S. *Sultan*, carrying 10-inch muzzle-loading rifles and quick-firing and machine guns.

In the absence of a record of the firing it may be assumed that the ranges and number of rounds were sufficient to enable one to draw a reasonable conclusion as to the utility of a gun so mounted.

The firing had no effect on the target.

The following conditions favored the ship:

The weather was good.

The locality, both as to land and water, was probably better known than would be defenses of an enemy.

The defense was passive.

The dummy would be more readily disabled than a gun thus mounted for service.

The interval between the appearances was uniform except for a temporary accidental variation, which probably had little, if any, effect on the firing.

There was only a single gun to engage the ship's fire, and no other defenses were supposed to interfere with the deliberate action of the vessel.

Of course these conditions as a whole are vastly more favorable to the ship than any possible case in war. Leaving out all considerations

of danger to the attacking vessel from the fire of the defense, and of the decreased accuracy of fire due to battle conditions generally, a gun thus mounted for war service would be a much more difficult target than the dummy. The gun and carriage would be painted with the most favorable color for concealment, or if practicable would be entirely obscured by shrubbery. The use of smokeless powder would give no clew to the position of the gun, and at any range possible for a fleet at the beginning of an attack there should be absolutely no target.

It is scarcely necessary to call attention to the fact that a vessel of an attacking fleet could not confine its attention to a single gun of the defense.

The trial is instructive in showing what a ship may be able to do after the torpedoes have been picked up or destroyed, the defensive fleet defeated, and the fortifications abandoned. The conclusion is inevitable that the office of ships is to fight ships and obsolete land defenses. A direct attack of a proper defense is simply out of the question.

Certain classes of ships are built expressly with a view to enabling them to run away from a contest in which they may find themselves overmatched. But never in a naval fight can one vessel overmatch another to the extent that land fortifications overmatch all vessels.

It would be interesting to know what practical lessons have been learned from the trial above cited, and how many batteries have been constructed using the results of the trial as a basis in computing the protection required.

For mortar batteries, in which the safety of service is incomparably greater, the problem may be stated thus: A ship, under the most favorable circumstances for target practice, can not disable a gun in full view when served on a disappearing carriage. What are the chances that a ship in actual war may seriously interfere with the service of a mortar battery at a greater and unknown range when the ship has no means of determining even the general direction of the battery?

It must be admitted that this in itself might be considered a misleading statement of the problem, but it is only intended as a contrast to the opposite extreme of unnecessary protection. The statement of absolute safety to the disappearing carriage is of course an exaggeration, and there will generally be other conditions to be provided for beside the simple question of cover from the fire of attacking ships. Many positions must be able to resist siege operations or sorties by landing parties. But it is believed that the danger from such sources is often exaggerated, and that the isolated position of the United States justifies a comparatively open defense of its principal ports. Besides, the great volume, power, and accuracy of the fire from rapid-fire and machine guns make the defense against such operations so easy as to be practically a bar against their attempt unless the fight be already practically won.

The gun, which is in itself an item of great expense, does not form a

very large proportion of the cost of a battery, and a system involving so great an expense in the unit of fire does not admit of indefinite expansion. The maximum efficiency should be obtained with each gun, and this can be secured only when a certain amount of deliberation is practicable. Reasonable cover is required for such deliberation as well as for the protection of the gun and carriage. Facilities should be provided for eliminating every vulnerable source of error in individual firing, and any other class of firing should represent the sum of trained individual effects.

To make the disappearing carriage fully effective the method of indirect laying should be used, with a view to reducing the time of exposure of the gun in the firing position to the lowest practicable limit, which is a point of great importance when the battery presents a good target. With well-screened batteries the time of exposure may not be of much importance, and either the direct or indirect method of laying may be used. But the latter admits of very great refinement, and it is believed that by it the most effective fire may be obtained. The direct method is always available in an emergency if the indirect should fail, while the latter is generally a necessity if the use of brown powders be assumed.

The use of smokeless powder gives increased advantage to the defense by facilitating range finding, by not betraying the location of disappearing and mortar batteries, and by affording a better and quicker estimate of the effect of the firing. The corresponding advantage to an attacking fleet is not great except when attacking batteries which present good targets.

It may be stated as a sound principle that when excellent natural cover is provided, as on very high elevations or in mortar batteries, it is much more important to increase the number of guns than to afford much additional and expensive protection. Here the probability of being disabled can scarcely be great enough to interfere with the desired deliberation in serving the pieces.

Also, in the most exposed situations, *when the site is very contracted*, the cover should be made as nearly perfect as practicable. Shoals between channels, very small islands, and outlying shoals are good examples. Under any circumstances the volume of fire from such positions would be small and very expensive, and in general such points would be fortified only when sufficient provision for the defense could not be provided elsewhere. Turrets and armored casemates are naturally suggested for such sites.

Exposed sites which are also extensive may give rise to some difference of opinion as to the details of the defense. The question will not be as to the use of disappearing carriages, but as to the extent of such use. The defense will generally include armored casemates, detached forts of some command, and low relief batteries with disappearing carriages.

The disappearing carriage does not make the distinction between the two latter types of batteries, as both systems should be armed with guns under cover while loading and exposed only when firing. The low batteries form the widest field for that form of disappearing carriage in which the disappearing principle is involved in the mechanical construction of the carriage itself. Barbette carriages mounted on disappearing platforms will probably be limited to the detached fort, as their use on low sites would generally involve very expensive excavations. The disappearing carriage is equally applicable to both types, and it is probable that its development and application to high calibers may prove its efficiency and economy for all cases requiring artificial cover. Its adaptation to very exposed turrets would be the most difficult, but from the point of view of the mechanical engineer the difficulties of the problem do not seem to be insurmountable.

When the character of the site is suitable to either system the comparison is, of course, one of efficiency and cost.

Except with disappearing platforms it is an imperative condition that all carriages shall be capable of being maneuvered by hand with sufficient ease and rapidity for effective service. At the same time the desirability of an efficient power service is beyond question. Electric power is undoubtedly the most convenient to apply and operate. It does not require a separate steam plant, from the fact that the electric light must in all cases constitute an important factor in the defense. The amount of power required is small, and the lighting plant can readily be used for the service of the necessary motors. A well-designed ammunition service will also probably employ electric power, particularly if the guns of the defense be separated by considerable distances. In fact, electricity is of such vital importance in its various uses that practically no additional complication will result from its application to the maneuvering of guns.

Of course any system involving a complete power plant for its own service will be provided for without electric appliances.

The whole question of the application of power for artillery purposes seems to be on a very strange footing. The tendency seems to be either to use it exclusively or to reject it entirely. My own opinion is that neither of these extremes is wise. It is not difficult to devise a system which shall admit of working satisfactorily by hand and at the same time have its usefulness materially increased by the application of power. As soon as an attacking fleet comes within a good fighting range the superiority of the shore batteries should be made evident at once. Rapid and accurate fire is necessary for this purpose, and power appliances are very potent factors in increasing the rapidity of fire. The mounting of the greatest number of guns consistent with economy, and the proper handling of these guns, may constitute a very complete defense with comparatively little expenditure for forts. At the same time the defense, by a proper confidence in its resources, might permit

an approach within a zone from which an attacking fleet would find its retreat extremely hazardous.

This immediate development of a very powerful and accurate fire is of vital importance in any case where an attempt to run the batteries would be practicable. Its necessity is not so obvious when such an attempt must be preceded by a deliberate trial of strength between the contending forces.

But after Alexandria who would expect a fleet to attack a properly defended harbor? The risk would be unwarranted, ships being too valuable for other purposes to justify their taking the chances against efficient land works. Even their success would probably involve a new trial against the home navy while in no condition to continue the fight.

But little can be said as to the details of defenses without having a particular case under discussion. In no case can the question admit of a definite mathematical solution, and individual judgment must be very prominent in determining the approximate value of the different elements affecting the problem. Any contribution to engineering effort in this direction which is marked by distinct radicalism can be of comparatively little value. As far as the application of the disappearing principle in carriages is concerned, it seems that the time for a very valuable presentation of the case has not yet arrived. We have not yet passed the experimental stages, and the profession generally is hoping for something better than anything which has yet been offered. This paper is therefore discursive and incomplete, and anything like a thorough technical treatment is now impracticable, even if such treatment be desirable for the purpose in view. An expression of individual opinion may be valuable in attracting closer attention to the subject, and it is hoped that the profession may recognize possibilities of progress in this direction which shall dwarf our present accomplishment.

In my judgment a much more favorable comparison for the disappearing carriage can be made than now warranted from the standpoint of the strictly military engineer. Traditions can generally be discredited only by achievement, and the conditions have been unfavorable to rapid progress in appliances for handling heavy ordnance. The carriage problem belongs to the province of the mechanical engineer, and governmental methods do not, as a rule, offer sufficient inducement for great effort. This is particularly true of the republican form of government, and in other forms of government the close corporation methods have limited the field from which improvements might be expected. Most of the mechanical talent of the world is busy in other fields, and can not easily be diverted, while the military profession contains comparatively few men whose education and natural ability prompt them to do more than simply to study the military value of the appliances in use or proposed for test. The possible is a

hidden province to him who sees nothing except what is in material shape before his eyes.

It is quite natural to look for a certain amount of partisanship in the presentation of a subject by one whose own designs are involved in the discussion. Such discussions are generally discounted in advance, both as to general treatment and comparison of methods. It is hoped that in the present instance the partisanship may not appear offensive.

The argument in favor of a wider usefulness for the disappearing system is based quite as much on what I believe to be a comparatively easy future progress, as upon what has already been accomplished. This is, of course, intangible to him who believes otherwise, and for him it can form no proper part of the discussion. Such a consideration is necessarily ignored in the work now designed or in progress, it being the duty of the military engineer to provide the defense which experience has shown to be best. At the same time the subject is certainly of sufficient importance to warrant a further development of the disappearing principle, which should be carried to a point where an approximate final comparison may be made with more expensive mountings for all high-power guns.

It is assumed by some that the necessity for disappearing carriages is more apparent than real, even on exposed sites, and that barbette guns may be made to answer every purpose. In a certain sense this may be true. That is, for a given cost more guns can be mounted in barbette than on disappearing carriages, and the defense could thus be made effective against any probable attack. But such a defense would certainly be more liable to invite attack, and during the fight many guns and carriages would be disabled, while effective service of the batteries might be prevented by rapid fire and machine guns. Even if successful the fight would probably end with fewer guns serviceable than if a smaller number had been originally mounted on disappearing carriages. The importance of living "to fight another day" should be recognized, as well as the more immediate advantage of success in the first instance. The disappearing carriage may therefore be a more permanent and economical means of defense, notwithstanding a somewhat greater original cost per gun. And incidentally the saving of a few men may be of some importance, at least to those whose lives are to represent the difference between the two systems.

After all, the object of a perfect defense is to form a permanent insurance against the levying of tribute and the destruction of life and property, and to act as a preserver of the peace of nations.

It is not contended that any particular form of battery should be adapted to the disappearing carriage, as the character of the site must have a controlling influence in determining this question. But, whatever form be adopted, it seems desirable to follow the general contour of the site when practicable, or to form an artificial line which shall give no readily distinguishable points for attracting hostile fire, except

intentionally, for the purpose of deception. A slight command may sometimes be necessary to properly cover all approaches, but differences of command which are inappreciable in affecting the angle of fall should be avoided unless the advantage be so apparent as to offset the very evident disadvantage of presenting an easy target. An increase of 40 feet in command gives an advantage of about one-fifth of a degree in the angle of fall at the maximum penetrating range, and a ship can not, in a regular attack, come far within the penetrating zone without very great danger, unless the fire of the defense has been well kept down by the attacking fleet. It is not probable that so slight an advantage would have much influence on the issue of the fight. As far as the advantage in cover to the battery is concerned, it is easier to secure such advantage by modifying the details of the mounting than by increasing the command. Even at a range of 1,000 yards an advantage of 40 feet in command increases the angle of fall only about three-fourths of a degree. It also decreases the angle of arrival by the same amount, but it is very easy to design the carriage so as to give this amount of additional protection if necessary, while with the lower battery it may be much easier to obtain the necessary thickness of earth to resist direct penetration.

But ranges of 1,000 yards should be impossible. If the depth of water be favorable to such an approach, it should be prevented either by an increase in the number of guns available at longer ranges, or by sufficient command and protection in those which are open to such an attack. This, of course, on the assumption that the conditions are not favorable to the use of submarine mines.

But even if the defense should fail to force the fighting at a sufficiently long range to most largely discount the fleet in accuracy of fire, still there is vast compensation to the defense in the fact that with every approach of the ships there is an increase in the accuracy of fire and power of blow, while the advantages to the fleet can be correspondingly great only when firing against barbette guns. But barbette mountings are not under discussion for batteries of low relief.

When ships may select their own positions at leisure and anchor at small-arm ranges, as at Alexandria, the effect of the fire is very materially modified by small differences of command in the defensive works; but the defense of Alexandria was not modern, either in its equipment or conduct. The conditions which there made the question of command important would be absent in case of an attack against modern defenses. The lesson of Alexandria is that the chances against a successful naval attack of land fortifications are so great that even defenses which are now considered obsolete may still be of great value. It is not probable that any important harbor will ever be attacked with as many chances of success as in the case of Alexandria; and even there a garrison belonging to any one of the great nations of the world might have produced a very different result. The fleet had a very narrow margin in its favor

at the end of the bombardment, leaving out of consideration the demoralized condition of the personnel of the defense.

Another point to be considered is that guns admit of no useful firing at less elevation than the angle corresponding to the least fighting range. On many sites this is a very considerable angle, and hence it would be needless exposure to mount the guns so as to be able to fire at a less angle. Such sites may be made to provide a material increase in protection over that required in the normal disappearing carriage, which is adapted to firing at a depression of 5 degrees. Thus, suppose a 10-inch carriage designed to fire at a depression of 5 degrees, and to protect from an angle of fall of 10 degrees through the interior crest, conditions which disappearing carriages have been required to fulfil. If the site be such that the least useful angle is 1 degree elevation, then the carriage can be lowered so as to give protection from an angle of fall of 14 degrees. This is a very large increase over the original requirement, and it would make the protection well-nigh absolute in the loading position, while the exposure would be slight in the firing position. Some sites may even afford opportunity for very effective firing without ever exposing the gun to view.

Closely allied to this subject is a system of range-finding which shall give a permanent record of the time and space coördinates of ships. For all practical purposes this may be made automatic and accurate. By such a system the present power of any defense may be very greatly increased by a very small increase in cost.

It is not practicable to make a proper study of a single element of a defensive system without considering the intimate relations of all the parts, both as to mechanical details and principles of military engineering. And even in advance of this there must be a clear conception of the proper method of utilizing all the forces which are to be provided.

This is an artillery question, and it is necessarily left to the artillery for final solution. But inasmuch as there seems to be great differences of opinion as to the value of certain new appliances which have been proposed, particularly among those who have seen active service under old conditions, it may be well to call attention to the fact that efficiency requires some changes in methods as well as in appliances.

Between the extremes of impracticable simplicity and unnecessary complexity there is a wide field for intelligent judgment. A modern defense is impracticable without many appliances requiring intelligent care in their use and preservation. In many private establishments of very great intricacy we see the work going on smoothly every day, even under relatively more difficult conditions than may generally be expected in our coast defense. There is generally a conspicuous absence of work which has nothing to do with the business, and the fact that the establishment has been running steadily during the present year is the best guarantee that it will continue to run next year.

The military service has much to learn from ordinary business methods. There is a very great advantage in making the tenure of office depend on the payment of dividends. Military command, at least, should stand on a similar footing.

Heavy artillery service, particularly in time of peace, has properly very little in it of what we generally associate with the military idea. The legitimate work of those who are depended upon to defend our coast by the use of heavy guns does not readily lend itself to the creation of that spirit which is essential to the efficiency of the soldier. The discipline, respectful bearing, and perfect obedience which are the measure of a soldier's value, seem to require constant use of the tedious routine of the drill regulations, and there is generally sufficient attraction and variety in field service to readily inculcate those principles. Heavy artillery is at a great disadvantage in this respect, and the consequence has been that artillery recruits in our service have been made much more proficient in the use of the Springfield rifle, and in infantry drill generally, than in the handling of heavy guns. But the military spirit is necessary for the fort as well as for the field. The vacancies in the enlisted force of the coast artillery might be filled by reënlistment or transfer from the infantry, cavalry, and field artillery. An excellent force could thus be selected, and many men of beyond middle age who would find active service in the field too exacting might still make most efficient artillery soldiers. The whole energy of the artillery should be utilized every day in the year in attaining the single object of knowing how to hit. The art of shooting is very easy, but the science of hitting is extremely difficult.

In most of our harbors but little opportunity can be had for heavy firing, principally on account of the demands of commerce; but with the mean deviation of the guns known, very little of such firing will be necessary. In the short period between the declaration of war and any probable attack it will be easy to secure the necessary target practice to establish the mean error for each gun as mounted. The important question is the daily use of all the means of defense. All the guns should be maneuvered every day, and the aim should be to keep them always ready for action. The practice necessary for making expert artillerists should consist in tracking vessels entering the harbors, maneuvering the guns into the proper positions, and firing with electric primers. The instant of firing should be recorded, together with the azimuth and elevation of the gun. The shot should be marked on the chart, together with the time of striking; the direction of the shot, and the dangerous space. The ship should be marked on the chart in the position it had at the time of striking, and the accuracy of fire is then seen at a glance. The plotting of the shot of course involves the effect of wind, drift, time of flight, and angle of fall.

Constant practice of this kind would soon demonstrate the possibilities of the system. The number of deliberate aimed shots which

could be delivered at a ship entering the harbor is, then, not a matter of conjecture, but simply a question of daily practice. What is expected to be done in an emergency should be done all the time.

A system of this kind is essential to the most efficient use of disappearing carriages. Its application to other forms of mounting is evident; but only in the case of disappearing carriages can it assist in the concealment of the batteries, and this point can not be made too prominent.

It has been urged that the disappearing carriage does not afford sufficient protection. Certainly not of itself, if it is to be made an easy target. In such case additional and expensive protection must be provided in the form of fortification. This is necessary on some sites, but when the site is favorable, the battery may be made almost as secure as a mortar battery.

But there is a great deal of protection in being able to shoot straight and often, and this power can not be acquired by a few days of desultory target practice during each year. Incessant labor on the lines here indicated will develop the system so that it can be readily handled and the results can be quickly obtained. At the same time many expedients will be suggested, by which the positions of ships may be accurately known, without resort to all the details of the system. Thus, for instance, by constant familiarity with all points of approach, including depth of water and width of channel, the daily use of the tracking system will develop critical points where a ship may be readily located within the combined dangerous space of several guns. Special signals may be used for covering such points in a harbor, and, having the azimuth and elevation for these points distinctly marked, the guns can be laid immediately and prepared for firing without delay. For such firing, at least, the directions should be given and the circuit closed by the commanding officer from his observing station.

This is not the place to mention the numerous details of such a defense. They go without saying, but not without doing.

This digression has been made for the purpose of emphasizing the fact that a single element of the defense, and particularly a comparatively new and untried type of machine like that under discussion, can not be properly judged apart from its place in the complete system, and also that the usefulness of the whole system must depend on intelligent manipulation.

But little has been attempted by way of providing a disappearing carriage for siege service, although the desirability of better protection is evident. The volume, power, and accuracy of the fire accessible to the defense against siege operations has reached a higher state of efficiency than any other kind of fire, and either better protection or great preponderance of artillery is essential to the attack. The rapid-fire gun gives the defense the most effective weapon known for guns up to 6 inches in caliber, and it is difficult to see how the attack can meet

this advantage without disappearing carriages. Of course, the rapid-fire guns are available for the attack also, but under much less favorable conditions for effective service. Were it not for the fact that a besieged army has generally been already defeated in the open field, it would be extremely difficult to make much impression on well-constructed and properly armed defenses, unless the superiority in men and material be vastly in favor of the attack. A thoroughly efficient disappearing carriage would do much toward restoring the equilibrium.

It is an open question whether or not the old conditions as to mobility should still be insisted upon for siege batteries. The railway is a necessity for the proper supply of an army, and will certainly be present as a factor in all siege operations. There will therefore be no difficulty in transporting any form of carriage suitable for the attack and it would be wise to adopt some form of disappearing carriage involving great certainty and ease of action, together with very good cover. I do not believe this is practicable as long as the weight of gun and carriage is limited to what is desirable in a single vehicle. The weight of the carriage alone might, if desired, be thus limited, which would simply involve separate transportation for the gun. This would be entirely satisfactory, even without railroad transportation, as it would not affect mobility except by increasing the length of the train. The carriage could then be made much more efficient than is practicable with the usual limit as to weight, and the effect on mobility would be inappreciable.

With regard to particular types of the disappearing carriage, no attempt will be made to follow the subject historically, but the latest forms will be described in sufficient detail to show present progress.

In England the Moncrieff designs have developed into the well-known Elswick hydropneumatic carriage, which is practically the only carriage on the disappearing principle which has yet reached much success beyond the experimental stages. In fact it is the only one which has gone beyond the experimental stage for guns of high caliber and power. Many have been built for service for various calibers, including a number for 13.5-inch guns of 67 tons weight. They are reported to have been successful under severe tests.

In the Elswick carriage the gun revolves about a fixed horizontal axis perpendicular to the plane of fire. The details of the various designs differ greatly, and to show the flexibility of the general design, I have selected three different carriages for description. The descriptions are taken from Mr. W. Anderson's lectures before the School of Military Engineering, Chatham, England. These lectures are published in the Professional Papers of the Corps of Royal Engineers, and reprinted in Notes on the Construction of Ordnance, No. 55, issued by the United States Ordnance Office:

ELSWICK HYDROPNEUMATIC CARRIAGE FOR 9.2-INCH B. L. RIFLE.

(Plate I.)

The body of the carriage consists of a pair of V-shaped frames (A) made of boiler plate and angle iron, attached at their apex and lower end to a cast steel pivot (B) working in a pivot plate (C) embedded in and secured to the masonry or concrete at the bottom of a well formed in the middle of the gun pit. The upper ends of the frames are connected solidly together by cross frames and supported by six horizontal rollers or trucks (D), which run round a cast iron roller path (E) secured to the masonry of the upper edge of the well.

Through the forward upper portion of the frames passes a wrought iron rocking shaft (F), on to which are keyed a pair of wrought iron levers (G), the upper ends of which are formed into bearings for the trunnions of the gun and fitted with cap squares.

Between the levers, about one-third of their length from the fulcrum, is placed a cross head (H), into which is keyed the upper end of a connecting rod, the lower end of which rests in the bottom of a hollow plunger or ram (I), sliding through a gland, packed with leather or hemp, into an inclined cast iron cylinder (J) bolted securely between the two frames.

The plunger is a little smaller in diameter than the cylinder, but terminates in an enlargement or piston, which fits the bore and serves at once as a guide, an automatic throttle valve, and a stop to prevent the ram being forced out too far. To the lower forward end of the cylinder is fitted a recoil valve communicating with two wrought-iron air vessels (L) placed inclined, parallel to and under the cylinder. From the lower end of the air vessels a pipe, controlled by a screw stop-valve (M), communicates with the upper end of the cylinder just below the gland. This connection serves for raising the gun into the firing position, and the port or passage by which the pipe enters the cylinder is so arranged that the piston end of the ram, as the gun rises, gradually closes the opening, and so brings the gun gently to rest.

The elevating arrangement consists of a pair of trunnions (N), secured in any convenient manner to the breech end of the gun; of a pair of elevating bars (O), the upper ends of which are attached to the trunnions by elastic connections, and the lower ends turn around a shaft which crosses from side to side of the frames, and the ends of which are fitted into slide blocks working in guides (P) secured to the inner faces of the frames.

The slide blocks are elevated by screws passing through them, and the two screws are turned simultaneously by bevel wheels actuated by a shaft common to both, crossing the frames and brought into motion through bevel gear by means of an inclined hand-shaft (Q), which can be actuated either from the level of the gun-pit or from the bottom of the well.

The training gear can also be operated either from the upper or lower level of the emplacement.

A rack (S) is formed just below the roller-path in the casting forming the upper margin of the gun-well. Into this rack gear a pair of pinions, actuated by vertical shafts passing up through the deck over the well into gearing pillars (R), secured to it and having hand-shafts connected with the vertical shaft by means of bevel gear. The lower ends of the vertical pinion shafts are produced downwards and by means of inclined shafts are also operated, through bevel wheels, by a hand-shaft (V), attached to the lower ends of the main frames.

The well is completely decked over by splinter-proof plating (W), and access to it may be obtained either by trap-doors through the deck and ladders, or by a covered way from the side.

To protect the men loading, a screen (X) is fitted to the framework and revolves with the carriage. An aiming platform may be arranged to suit the particular situation of the emplacement.

Two sets of small pumps (Y) are fixed, one on each side of the main frames, and actuated by hand wheels, one set for charging the air vessels with air, and the other for lowering the gun from the firing to the loading position by pumping water from the cylinder into the air vessel.

The following are the principal dimensions:

	Ft.	In.
Diameter of gun pit	30	0
Depth of ditto	10	6
Diameter of well	20	0
Fall of gun vertically	10	6
Length of path described by trunnions	17	6
Diameter of recoil cylinder	0	30
Stroke of ditto	5	3
Depth of well	12	0

Average air pressure, 234 pounds.

ELSWICK HYDROPNEUMATIC CARRIAGE FOR 10-INCH B. L. RIFLE.

(Plate II.)

The body of the carriage consists of a pair of wrought-iron beams (A) connected together so as to form a solid frame. Towards the middle of the lower side of the frame is a pivot plate (B), fitting on to a pivot piece (C), securely bedded in the masonry or concrete of the emplacement. The outer ends of the frames are carried on two pairs of cast iron wheels or rollers (D), traveling on a roller path (E) embedded in the floor of the emplacement.

On the upper side of the frame, toward the middle, are secured a pair of cast-steel pedestals (F), which carry a wrought-iron rocking-shaft (G), on to which are keyed a pair of bent wrought-iron levers (H), the upper ends of which are formed into bearings for the trunnions of the gun, and fitted with cap-squares.

The lower ends of the bent levers are connected by a wrought-iron shaft (I), round the middle of which is clasped the outer end of a con-

necting rod, the opposite end of which abuts into a recess in the bottom of a hollow trunk or plunger (J), which works into the horizontal recoil cylinder (K), through a gland packed either with leather or hemp packing.

The plunger is a little smaller in diameter than the cylinder, but terminates in an enlargement or piston which fits the bore and serves at once as a guide, an automatic throttle valve, and a stop to prevent the ram being forced out too far.

The cylinder is of cast iron, and is secured to the side girders of the main frame.

Planted on the rear end and top of the cylinder are two automatic recoil valves (L), which communicate with two wrought-iron air vessels (N) placed horizontally, one on each side and over the cylinder. A branch pipe from the lower sides of the air vessels, common to both and controlled by a screw stop valve (O), serves for elevating the gun into the loading position, and communicates with the recoil cylinder close behind the gland at its outer end, entering it by a port which is gradually closed as the gun rises, by the passage of the piston-shaped enlargement, which forms the outer end of the ram, so soon as the gun is nearly up to its full height, thus bringing it to rest in a very gradual manner. Buffers (P) are provided to check the gun, both in its downward and upward movements.

The elevating arrangement consists of a pair of trunnions (Q) secured in any convenient manner to the breech end of the gun, and a pair of elevating bars (R), the upper ends of which are attached to the trunnions by elastic connections, and the lower ends turn round a shaft which crosses from side to side of the frame, and the ends of which are fitted into slide blocks working in guides (S) secured to the inner faces of the girders forming the frames.

The slide blocks are elevated by screws passing through them, and the two screws are turned simultaneously by skew-wheels, actuated by a hand shaft which crosses the carriage and is worked from either side by a hand wheel.

A scale properly graduated will indicate the degree of elevation of the gun.

To soften the kick-up of the carriage at the moment of discharge the front end of the main frame is fitted with a pair of short-stroke hydraulic compressors (U), the piston rods of which are attached to brackets (V) which slide along a rail secured to cantilevers (W) built into the wall of the emplacement and securely held down. The cantilevers carry a splinter-proof platform which runs round the gun-pit, and serves as a banquette from which the operations of the detachment may be directed and the gun laid.

The compressors act both ways—that is, they will resist the upward kick of recoil, and will also lower the carriage gently after the motion of the gun has ceased. The compressor cylinders are solid at the bottom, so that the liquid used, once filled in, can not leak out.

The training of the carriage is effected by hand wheels (X) on each side of the front end of the frame, which actuate the front wheels or rollers by means of suitable gearing.

The hand wheels and shaft for training can also be used for working a pair of pumps (Y) intended for forcing air or water into the air vessels, or for lowering the gun from the firing into the loading position. This is effected by pumping the water from the cylinder into the air vessels.

The men attending to the training and elevating are protected by the parapet from the enemy's fire.

The drawing shows an arrangement of a shield by which the detachment can be protected; also arrangements for facilitating the loading operations.

The following are the principal dimensions:

	Feet.	Inches.
Diameter of gun pit	32	6
Depth of gun pit	13	6
Fall of gun vertically	9	0
Length of trunnion path	14	3
Diameter of recoil cylinder	0	26
Stroke of recoil cylinder	3	8

Average air-pressure, 430 pounds.

ELSWICK HYDROPNEUMATIC CARRIAGE FOR 6-INCH 5-TON B. L. RIFLE.

(Plates III and IV.)

The body of the carriage consists of a pair of frames (A), composed of steel plates and angles tied together at each end by segmental arcs (B), which rest on a ring of live rollers (C), which in their turn travel round a fixed roller path (D), which forms part of a massive casting secured to the masonry of the emplacement. The live rollers are made with flanges at each end, which overlap the upper and lower paths, and thus afford both lateral and vertical support to the carriage and enable a central pivot to be dispensed with.

To the upper forward end of the main frames cast-steel brackets are attached, and take a rocking shaft (E), onto which is keyed a pair of cast-steel main arms (F), in the upper ends of which are formed the bearings for the gun trunnions (G), which are retained in their places by cap-squares, arranged to slide in under snugs in the arms, thus dispensing with bolts and nuts. The cast steel hydropneumatic cylinder (H) is fitted with trunnions (I) about its center, and is carried by bearings attached to the inner sides of the main frames (A). The cylinder has its air-vessel (J) cast on its back, and is fitted with a recoil valve (K), accessible through a cover conveniently placed.

The ram terminates at its upper end in a cross-head (L), which works on to a pin keyed into the main arms, and its lower end is formed into a piston of slightly greater diameter, which works in the truly bored cylinder, and serves as a stop to prevent the gun rising too far.

The valve (M), for raising the gun by opening a communication between the water space of the air-vessel and the cylinder, is in the bottom of the latter, and is actuated by a handle (N), conveniently placed at the rear end of the carriage, the said valve being also closed automatically when the gun has risen to the proper position by a cord (O), one end of which is attached to one of the main arms and the other to a lever actuating the valve. To prevent the gun falling too low, buffers (P) are fixed on the rear ends of the main frames, and so disposed as to receive the backs of the upper ends of the main arms just behind the trunnions.

The elevating gear consists of a pair of bars (Q), the upper ends of which are pivoted on trunnions, fixed to the breech end of the gun, and the lower ends to curved racks (R), which work in guides secured to the outside of the main frames; the racks are so curved that when the gun is in the loading position their traverse does not affect the gun. The elevating gear is operated by a hand wheel (S) on one side of the carriage, actuating the racks through a train of wheels.

The training of the gun is effected by hand gear (T) attached to each side of the forward end of the carriage. A large hand-wheel gives motion through a pair of bevel wheels to a vertical shaft, the lower end of which carries a pinion (U), which engages into a circular rack cast onto the base plate of the carriage. On the same plate is arranged a clip ring (V), into which engage clips in front and rear to prevent the carriage kicking up.

A chequered plate platform is attached to each side of the carriage, and covers the roller path and rack.

The Elswick carriage is a distinct type, and many modifications and imitations have been made or proposed. Among these are the Raskazoff, Armstrong, Noble, Canét, Saint-Chamond, and in this country the Pneumatic carriage.

The Raskazoff carriage was built by the Elswick company for the Russian navy. The modifications relate to the particular arrangement of the hydropneumatic system, without affecting the character of the motion of the carriage itself. The guns are mounted in a barbette turret, and they disappear only far enough to protect from a horizontal trajectory.

The Raskazoff siege carriage has similar motion also, but the gun is returned to the firing position by means of Belville springs. An hydraulic cylinder is provided at the lower end of the trail to take up the recoil, and the springs are strung on an extension of the piston rod. In the recoil the cylinder moves upon the rod and compresses the column of springs, and a check valve prevents the return of the cylinder to its original position. When the check valve is opened the springs force the cylinder back and return the gun to the firing position. The latter is accomplished by means of links connecting the cylinder with the lower ends of the arms on which the gun is mounted. A small

pump is attached to the cylinder, to pump the gun down when necessary.

In addition to the cylinder in the trail, there is the usual cylinder extending from the axle to the platform. In this case a centering wheel is fastened to the platform, and a rotating arm extends from the center of the wheel outward, with a lip turning under the rim of the wheel. The end of the piston rod is attached to the outer end of the rotating arm, this arm extending toward the front. The elevating device is similar to the Elswick, which is common to this class of carriages.

The Armstrong is an hydraulic spring carriage, springs being used instead of compressed air for returning the gun to the firing position. The spring tension is regulated by hand gear.

The Noble carriage is hydraulic only, the gun being returned to the firing position by a ram.

The Canét and Saint Chamond are hydropneumatic, but the details of the combinations differ from the Elswick and from each other.

The Pneumatic is, as its name implies, pneumatic only. This carriage will be described later.

The first serious attempt to provide a disappearing carriage for service in the United States was made at the suggestion of Capt. King (now lieutenant-colonel) of the Corps of Engineers. The carriage designed by him is of the counterpoise variety. The chassis is inclined to the rear, and while the gun and top carriage recoil down the incline a counterweight is lifted in a well under the front portion of the carriage, the top carriage and counterweight being connected by means of ropes passing over a fixed pulley between the front ends of the chassis rails.

This carriage was adapted to the 15-inch Rodman smooth-bore gun with entire suceess, but it never came into general use. Some difficulty was found in applying the same principles of construction to mounts for modern high-power steel rifles, and experiments with the design have not been continued.

The Schneider (Creusot) carriage is similar to the King in moving to the rear on an incline, but the details are quite different. So far as I have learned it has not been designed for guns above 6 inches in caliber. This carriage is intended to be mounted in a circular pit, and a shield is provided for closing the top of the pit.

The Chief of Ordnance, U. S. Army, acting under authority of a recent act of Congress, has entered into a contract with Mr. A. H. Emery for the construction of an experimental disappearing carriage for the service 12-inch breech loading steel rifle. The design has not yet been made public, and hence no description can be given.

THE PNEUMATIC CARRIAGE.

The Pneumatic Gun Carriage and Power Company, of Washington, D. C., has built for the United States Ordnance Department a disappearing carriage for the 10-inch B. L. rifle. This carriage has been tested at the United States proving ground, Sandy Hook, New Jersey, and is said to have performed its functions very successfully.

Pl. V shows the construction and use of the carriage so clearly that but little description is necessary. The motion is the same as in the Elswick, and the peculiarity of the carriage is that it is wholly pneumatic. Not only is the recoil taken up and the gun returned to the firing position by pneumatic power, but the same power is used for loading, elevating, and traversing. A small reversible air engine, located in a safe place within the main frame of the carriage, is geared to the elevating and traversing devices. The loading arrangement consists of a pneumatic lift for raising the charge and a pneumatic rammer for forcing it home. The arms on which the gun revolves are 10 feet in length, and in the loading position the gun is protected from an arrival of 7 degrees through the interior crest.

A steam plant is necessary for the service of this carriage, and the air is used under a pressure of about 1,000 pounds per square inch. The steam plant, with compressor and storage reservoir, is intended to be located in a safe place at some distance from the carriage.

THE BUFFINGTON-CROZIER CARRIAGE.

A few years after the King carriage was proposed Capt. Buffington (now colonel), of the Ordnance Department, submitted a counterpoise design. This design has lately been modified by Capt. Crozier, of the Ordnance Department, and two carriages according to the modified design have been under construction for several months. These carriages are for the 8-inch and 10-inch B. L. rifles, and it is expected that they will soon be mounted for trial.

The general plan is shown in Pls. VI, VII, VIII. The original design was without hydraulic cylinders, which constitute the principal feature of Capt. Crozier's modification. The counterpoise is in a well under the front portion of the carriage, as in the King carriage. Two parallel levers are mounted on a horizontal axis, which is journaled or trunnioned in the top carriage. The gun is mounted on the upper ends of the levers and the counterweight is attached to the lower ends. The top carriage carries the cylinders, and the ends of the piston rods are attached to the front of the main frame or chassis. During the recoil the top carriage moves to the rear and the counterweight rises, while the trunnions of the gun describe ellipses in passing to the loading position. The gun is sufficiently overcounterpoised to enable it to return readily to the firing position.

The elevating device is of the Elswick design, and the gun recoils

directly to the loading position irrespective of the angle of which it is fired. The loading position of the gun is shown in dotted lines in Pl. VI.

The hand wheels are for elevating and the cranks for traversing.

The protection is from an arrival of 7 degrees.

The carriage shown is for the 8-inch B. L. rifle, and the plates indicate the design so clearly as to make extensive and minute description unnecessary.

It was hoped that the carriage would be mounted in time to procure photographic illustrations for this paper, but this has been prevented by delay in completing the contract.

THE GORDON CARRIAGE.

(Designed by Capt. W. B. Gordon, Ordnance Department. Pls. IX, X, XI, XII, XIII.)

A heavy bed plate (A) supports two side frames (E), which carry the movable parts of the carriage on journals (E′), and a pivot plate (B) is permanently fastened to the under surface of the bed plate, the whole resting on a heavy cast-iron platform or traverse circle.

The gun is mounted on a top carriage (H), whose form is somewhat similar to the top part of the old style barbette carriage. Four double cranks (F E′ F′) are journaled in the side frames, two on each side. The top carriage is mounted on the inner and longer of the crank arms by means of two cross shafts (G), these shafts being journaled in the top carriage, while the ends of the shafts are securely fastened to the crank arms. A counterpoise frame (K) is mounted on the outer and shorter arms. During recoil the gun, top carriage, and counterpoise rotate about the journals (E′), the gun and top carriage describing an arc of about 180 degrees to reach the loading position, while the counterpoise describes an equal and opposite arc, rising while the gun falls.

The position and extent of the arc of recoil may be fixed at pleasure, so as to accommodate the carriage to the fortification in which it is mounted. It is an advantage to have the loading position as nearly under the firing position as the construction of the fortification will permit. The gun in the loading position is thus brought as near the parapet as possible, which secures the maximum amount of cover for a given fall of the gun.

The system is intended to be accurately counterpoised, and hence the recoil produces no motion of the center of gravity. The carriage as a whole is therefore a non-recoil system.

The gun, top carriage, and counterpoise remain parallel to their original positions throughout the motion. The elevating device (M N O P) is attached to the top carriage, and is independent of any other part of the construction.

The carriage is lifted on an oil pivot (C) for traversing, and a small hydraulic pump is provided for lifting the carriage. The oil is pumped through the pivot (C) into the cylinder (D).

The carriage is in complete contact with the platform except when traversing. The resistance to turning on an oil pivot is very slight, and the carriage may be moved by hand without any special appliances for the purpose, but any of the usual devices for traversing may readily be applied.

Between the side frames, and secured to the top surface of the bed plate, are two hydraulic cylinders (U) 12 inches in diameter. Above and across the front ends of these cylinders is an air chamber (W), separated from the cylinders by check valves opening toward the air chamber. A by-pass valve is provided for opening communication from the air chamber to the cylinders around the check valves.

The outer ends of the piston rods are carried by a wheeled truck which runs on rails fastened to the bed plate. From the shafts on which the top carriage is journaled, two parallel connecting rods (C^1) extend to the truck which carries the piston rods. During the recoil these connecting rods close like parallel rulers and run the truck and piston rods to the front, thus forcing the liquid from the cylinders through the check valves into the air chamber. Thus the energy of the recoil is stored in the air chamber, and it may be used to lift the gun to the firing position. The by-pass valve is opened for this purpose. A small air pump is provided to give the required initial pressure in the air chamber.

The aggregate cross section of the check valves is equal to that of the cylinders, and the hydraulic cylinders provide no part of the resistance necessary to take up the energy of recoil. The character of the motion is such that the velocity of the pistons is always less than the velocity of recoil, and the velocity of recoil is only about half that of a non-counterpoise system. The liquid, therefore, passes into the air chamber with a very low velocity, and no inconvenience is caused by foaming.

The stroke of the pistons is about 8 feet for a 10-inch carriage in which the protection is from an angle of fall of 10 degrees through the interior crest. In firing with a full charge the pressure begins at 80 pounds per square inch, and it rises to about 300 pounds at the end of the stroke. These limits can be changed at will by varying the amount of liquid used in the cylinders and air chamber. The strains caused by the maximum pressure are inconsiderable compared with the strength of the system, and the carriage is practically under no strain except during the shock of discharge. The very low pressure during recoil is due to the long stroke and low energy of recoil. The latter is only about one-fourth that of a non-counterpoise system. This estimate is made as follows:

Non-counterpoise system, velocity 2, mass 1.

Counterpoise system, velocity 1, mass 2.

Relative energy, 2 to 1.

In the non-counterpoise system the energy of fall for good cover is

about equal to the energy of recoil. Hence the relative energy to be taken up is about 4 to 1. This ratio is, of course, only approximate. In any particular case the energy is easily computed and an exact comparison made.

A counterpoise system in which the acceleration of the counterpoise is relatively low has less advantage in this respect. Considering the Gordon carriage as a rigid system of mass 2, as above, the counterpoise has the same acceleration as the gun, and this causes the low velocity of recoil used in the above comparison.

The carriage may be maneuvered by hand alone, and for this purpose a system of gearing is attached to each side of the counterpoise frame, and small platforms are provided for the men required in maneuvering. The gearing turns a pinion which meshes into a circular rack (Y) fixed to the side frame. The radius of this rack is equal to the length of one of the arms upon which the counterpoise is mounted.

The rear transom of the counterpoise frame is used as a loading platform. A charge is secured to the loading platform when the counterpoise is in its lowest position, and this charge is lifted to the loading position by the recoil.

The main parts of the carriage are of cast iron. The cheeks of the top carriage and the cranks and journals are of steel.

It should be understood that in publishing designs of carriages which have been built for test and not yet adopted for service, defects may be apparent which would be corrected in later constructions. This is common experience, even in building machines for ordinary shop use, where one might assume that all the conditions affecting the problem are known. Much more is this the case in handling high-power guns under fire with experimental carriages. It is generally unsafe to predict much as to results, particularly when the disappearing principle is involved. Weak points will generally be developed during the trials, and each difficulty must be met as it occurs. Foresight is extremely valuable, but the problem involves certain difficulties which, though possibly foreseen, can not be estimated until developed by firing.

At the same time the problem is a more or less definite one in mechanical engineering, and many features admit of a definite mathematical solution. But no one has yet been able to accurately estimate, except by experiment, the effect of time, elasticity, and mass in machines subject to heavy concussions. In some lines years of continued progress have shown that it is extremely unsafe and expensive to trust to computations based simply on tenacity and factor of safety. Form and mass have a controlling influence in absorbing concussions without destructive effect, and I know of no method, except by experiment, of determining the extent of the error involved in the assumption of perfect rigidity in masses subject to the action of impulsive forces.

With regard to my own design, its novel features, and the fact that it is essentially a non-recoil carriage, have made the problem very much less definite than any other with which I am familiar. It is easy to compute the stresses under the assumption of rigidity, and also the stresses during the motion after the shock of discharge; but the apparent magnitude of the problem of designing a non-recoil mount for a high-power 10-inch rifle, and the impossibility of computing the amount of the powder pressure which would be finally transmitted to the platform, resulted in an experimental carriage[1] which is much more massive than is necessary for service. And yet the weight of the gun and carriage, distributed uniformly over the area included within the extreme circumference of the cast-iron platform, amounts to less than 14 pounds per square inch. The carriage withstands firing with full charges with remarkable ease, and shows no evidence of great strain in any of its parts. The motion is extremely gentle for such a high-power gun, which gives 15,000 foot-tons of muzzle energy, and the velocity of recoil is so low that the compression in the air chamber is very nearly isothermal. A bucket of water placed on a horizontal surface of the counterweight was not overturned by the shock of discharge, and but little of the water was spilled. Tools can be left on the loading platform without being disturbed by the firing.

With regard to the peculiar motion of the carriage, I believe that it leaves nothing further to be desired; but the carriage, as a whole, can be made very much more compact and manageable, with great economy of space and with remarkable cover from hostile fire. The details are very simple and the air pressure is extremely low. In the experimental carriage the maximum pressure in the air chamber is lower than the minimum pressure in the case of the pneumatic carriage.

It is not my purpose to make extensive comparisons with other designs. Those who are interested in the subject have their own opinions as to the adaptability of designs to sites and as to the relative merit of the distinguishing features of the different designs. It is admitted that the purpose of the defense and the character of the site must have a controlling influence, but it is claimed that uniformity is practically of no importance in carriages for permanent works. Other things being equal, the carriage which can most economically give the cover required for each particular site should be the one selected for that site.

It should be remembered that heretofore there has been practically only one type of disappearing carriage applied to high-power guns, and any adverse conclusions drawn from this particular case should be held in abeyance until further experiments have been made with other designs. Assuming a satisfactory mechanical motion, it is obvious

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[1] The experimental carriage was built by the Morgan Engineering Company, of Alliance, Ohio. The carriage has been erected at the United States Proving Ground, and a number of preliminary rounds have been fired. It is expected that the tests will be completed during the present summer.

that a counterpoise system offers great advantage over the opposite type, at least for high-power guns of large caliber.

A short discussion as to the amount of cover obtainable is necessary in order to make a fair comparison, and this is naturally taken up after the details of the various types have been presented.

When the gun is carried to the rear on an arc of about 90 degrees the problem very rapidly increases in difficulty with the cover required and with the length of the gun. A glance at the various designs will show the advantage of coming down on an arc of 180 degrees, so as to bring the gun as close to the parapet as possible in the loading position. In the Gordon experimental 10-inch carriage the gun revolves on a radius of 4 feet 10 inches, and the cover obtained is 10 degrees for horizontal loading. In the pneumatic, and in similar designs, the radius of motion for a 10-inch carriage is about 10 feet, and the cover is 7 degrees for loading at an elevation of 7 degrees. This shows the comparative difficulty in complying with any condition as to cover.

In the outline design for a 10-inch carriage, Pls. X, XI, the radius of motion is only 4 feet 3 inches, while the carriage is lighter and much more compact and convenient than the experimental carriage. The counterpoise side weights are shorter and lighter and the loading platform is omitted. The gun in the loading position is close to the parapet, and no part of the carriage extends farther to the rear than the gun itself. It is therefore obvious that no system can give greater economy of space.

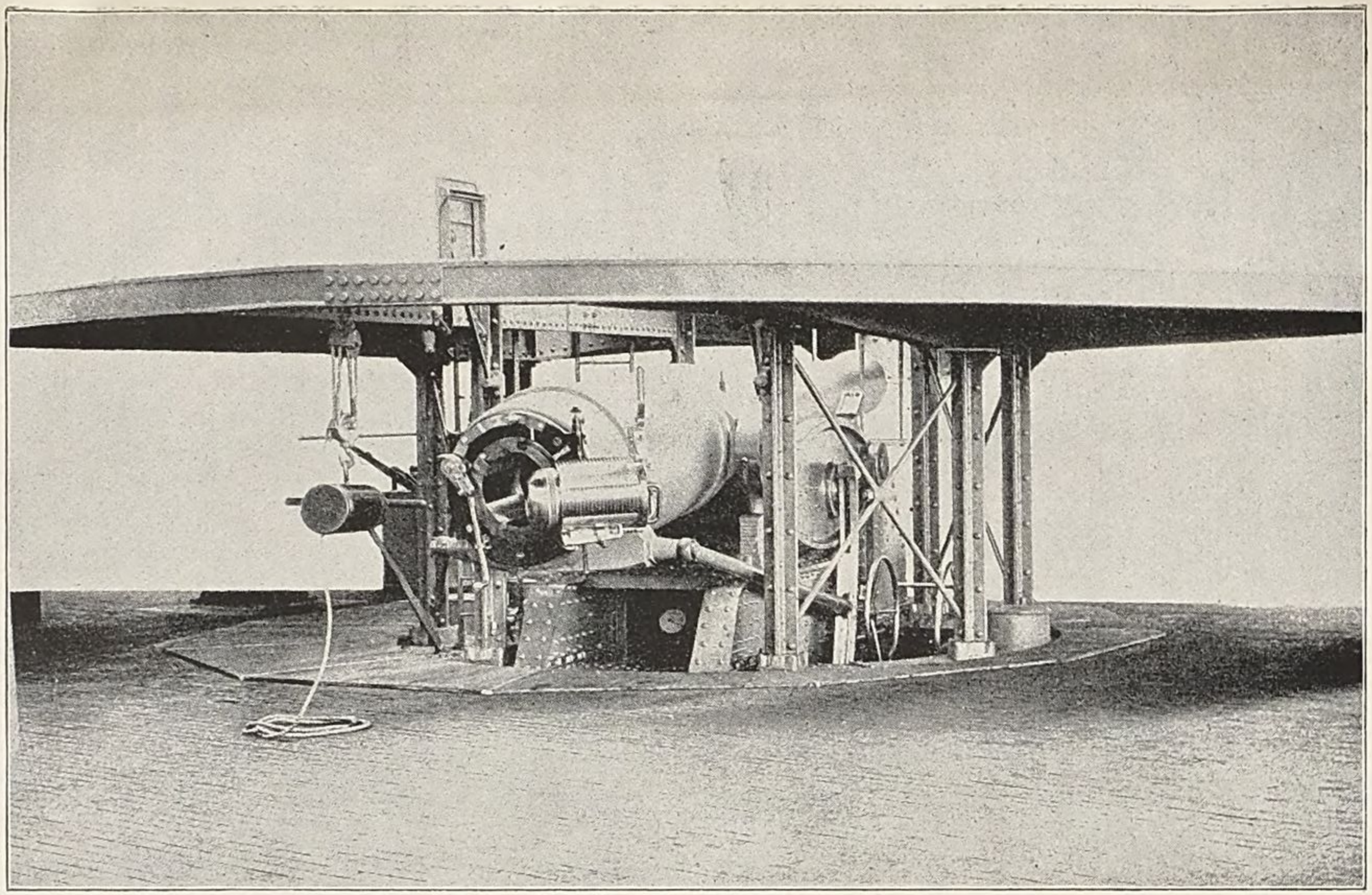
If the gun be loaded at an angle of elevation, as in other carriages, the protection can be increased about 2 degrees, making the cover 12 degrees. In the outline design of a 12-inch carriage for a gun of 40 calibers in length (Pls. XII, XIII) the protection would be similarly increased to about 19 degrees. But in either case such additional protection could be obtained, if desirable, by slight changes in the dimensions of the carriage, the design being so flexible that any reasonable condition can be complied with. The arc through which the top carriage revolves can be varied within wide limits, and a change in the radius of motion is about doubled in its effect on the fall of the gun. In the 12-inch design the fall of the gun is about 15 feet and the radius of motion is 7 feet 6 inches. The height of parapet is 27 feet 6 inches above the platform and 18 feet 9 inches above the ground level around the pit in which the platform is laid.

I believe that the difficulties in the way of constructing a satisfactory 12-inch carriage giving as much protection as demanded for modern guns of this caliber, with any other design which has been proposed, are, possibly, so great as to be prohibitory. This seems to be the present view of many military engineers with respect to all designs. But it seems to me that the evidence is not all in, and that the case is not yet ready for the jury. A close analysis of the Gordon carriage shows that it is as readily adaptable to high caliber guns of great length as to

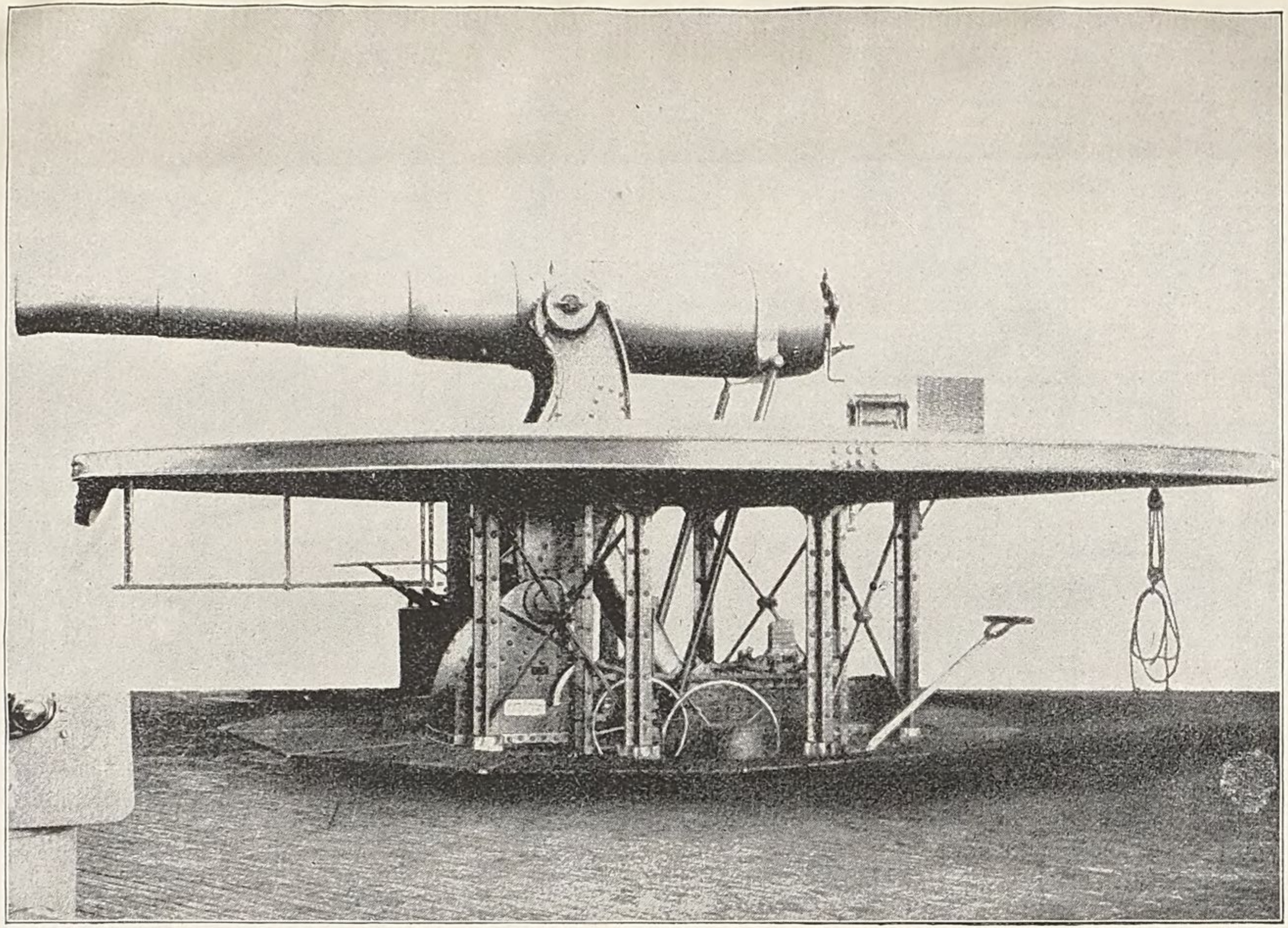
any other, and I believe this to be the case with no other design yet offered.

It is generally assumed that the business of war is to get hurt, and therefore the amount of cover sought is generally only what is necessary to make victory reasonably certain. In the ordinary chances of war there are so many variables, and so many personal considerations enter, that there can be no distinct line which limits a nation's moral responsibility in the protection of the lives of its combatants. The dispositions in the field are sometimes accidental and always more or less intimately connected with the personality of the officer in command. Everything is left to personal judgment, often exercised on the spur of the moment or with very little time for deliberation.

Such is not the case in a permanent defense, and I believe it is wise to keep this fact in view in designing our fortifications. The object of armies and forts is to prevent war, not to make war. It is very easy to provide an absolute defense against attack by sea, and at a very low cost considered as an insurance on the lives and property involved. It seems, therefore, to be unreasonable to assume that many casualties must occur in any case, and that we should stop short when we have given sufficient cover to keep the men up to their work. This is not taking the ordinary chances of war, for the protection can be made well nigh absolute with very little additional expense. Though it is held that such a defense should never be attacked, still the system would probably have to stand the test of war at least once. It then becomes a matter of importance to weigh a few dollars against the lives of good citizens. Even as a financial investment this would be good policy in a country subject to certain possibilities with regard to the pension list.



1. 9″.2 Gun on Hydro-pneumatic Carriage. Loading Position.

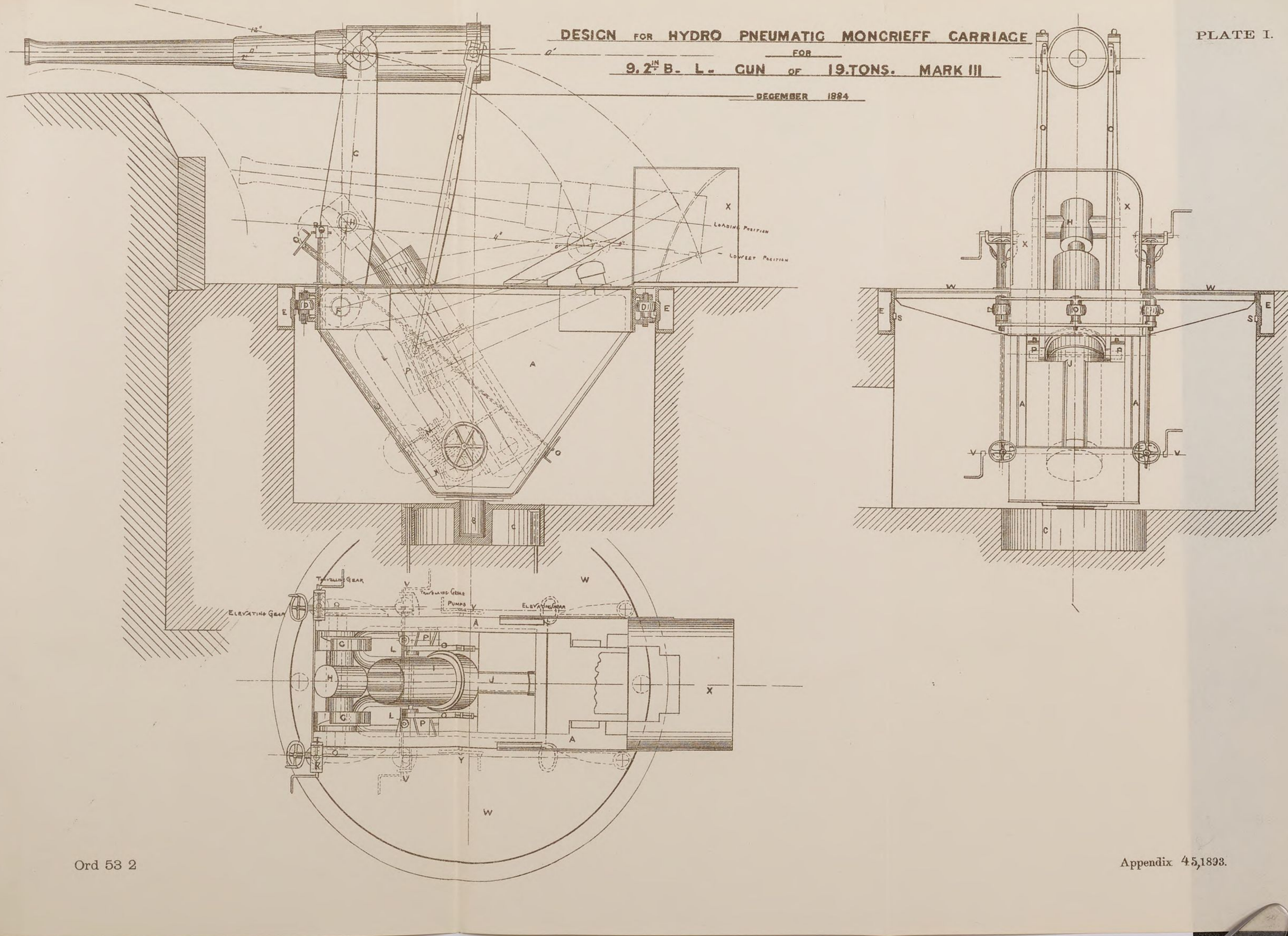


2. 9″.2 Gun on Hydro-pneumatic Carriage. Firing Position.

DESIGN FOR HYDRO PNEUMATIC MONCRIEFF CARRIAGE FOR 9.2 IN B. L. GUN OF 19 TONS. MARK III

DECEMBER 1884

PLATE I.



DESIGN FOR HYDRO PNEUMATIC MONCRIEFF CARRIAGE FOR 10" B. L. GUN OF 27 TONS. MARK I.

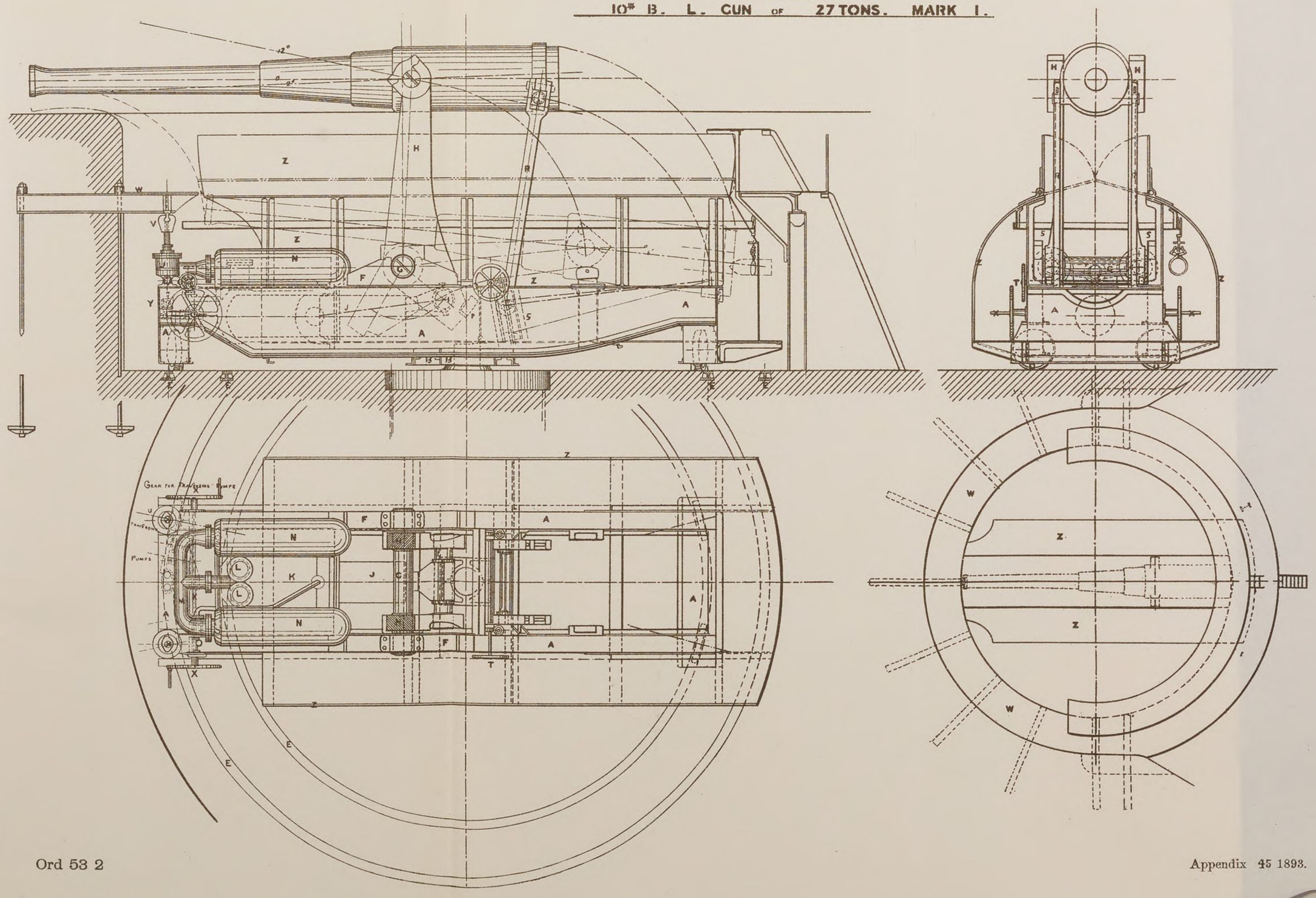
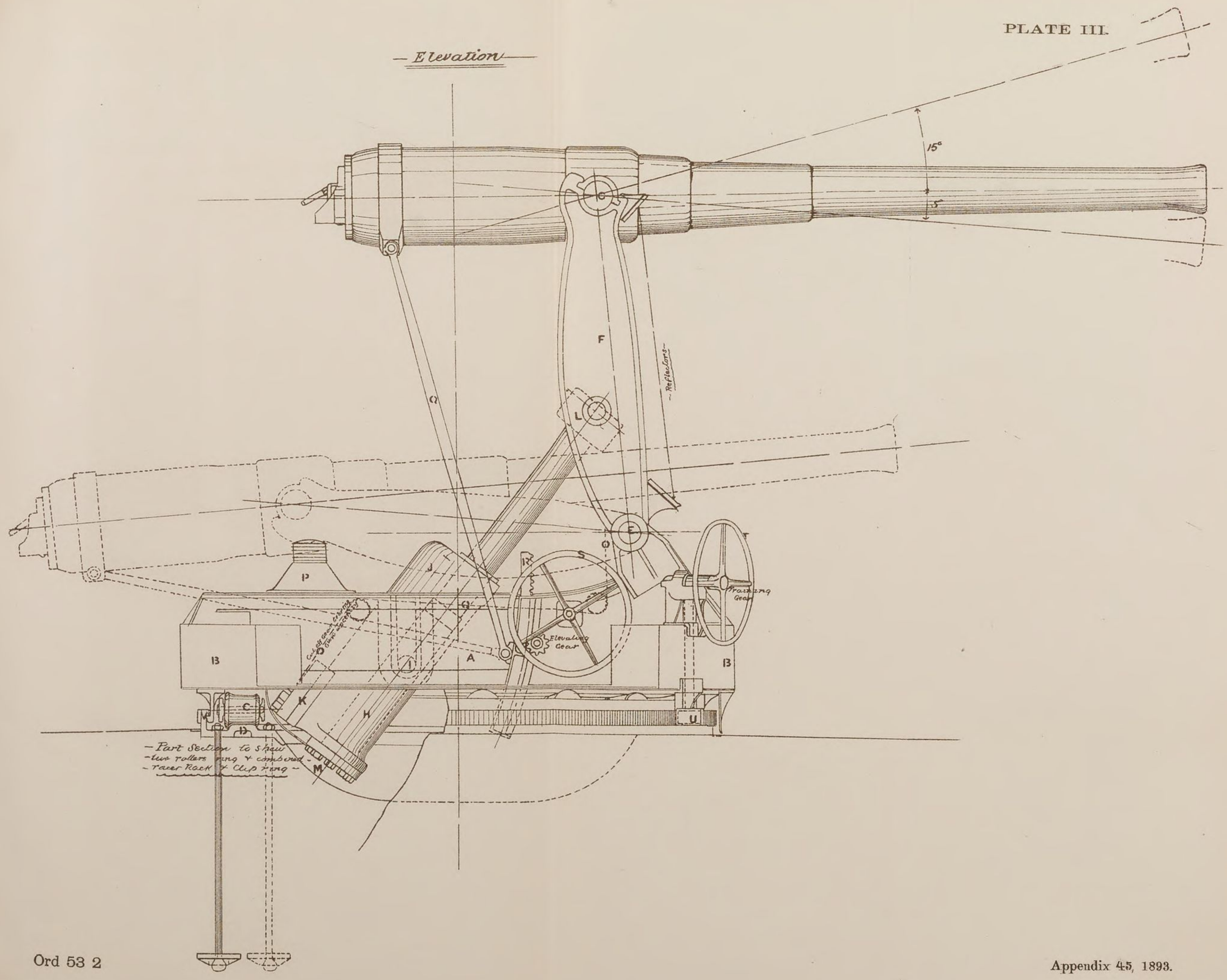
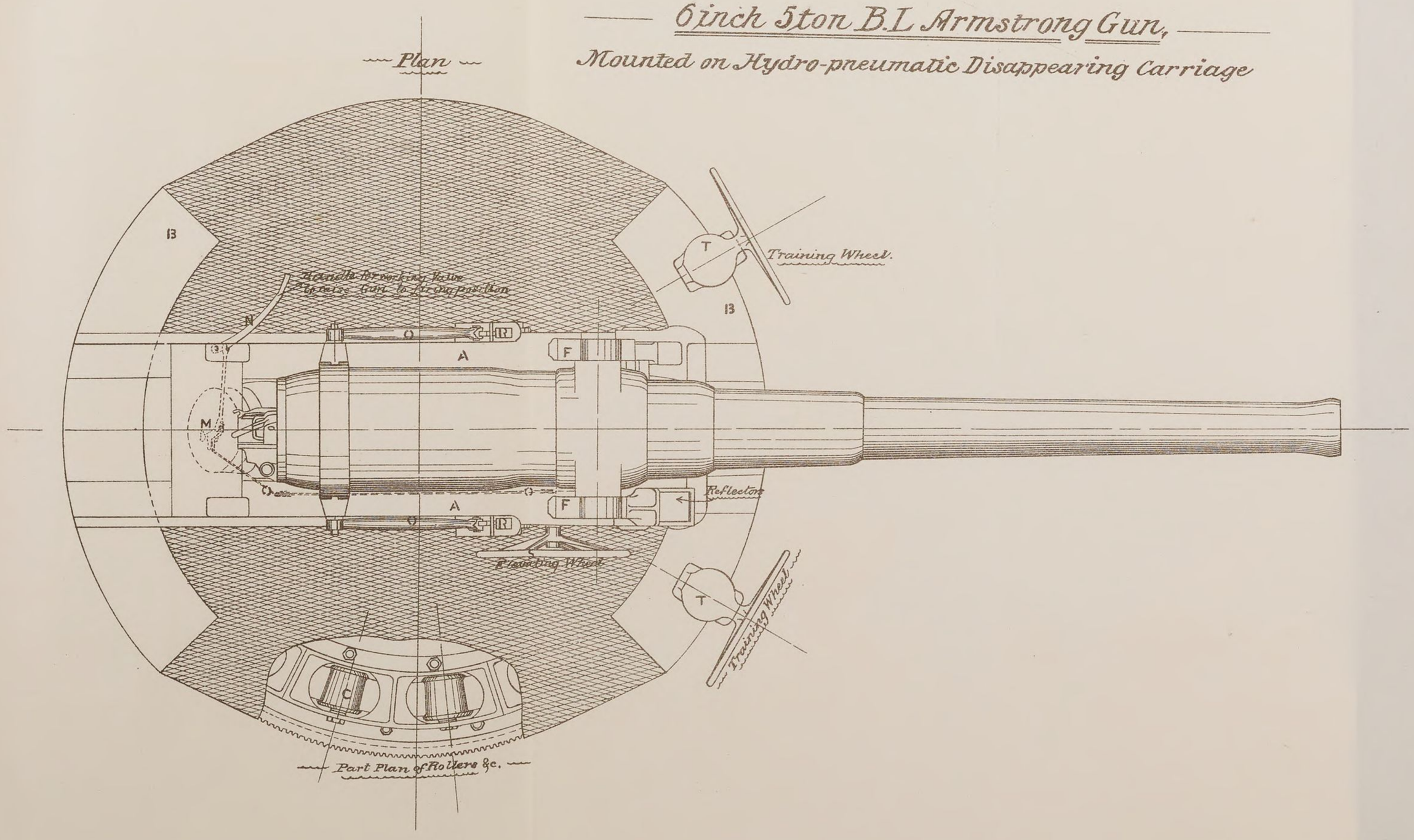


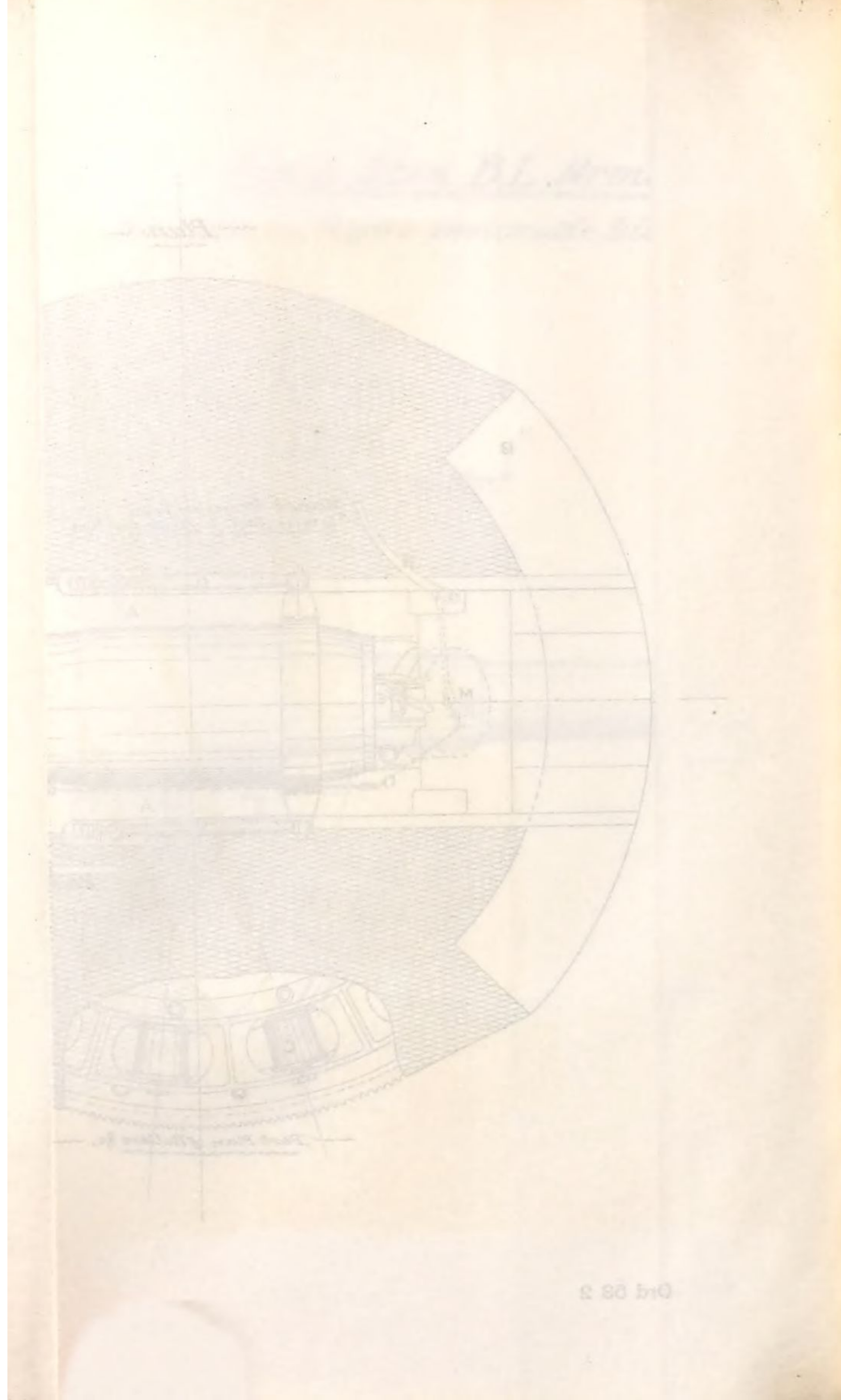
PLATE III.

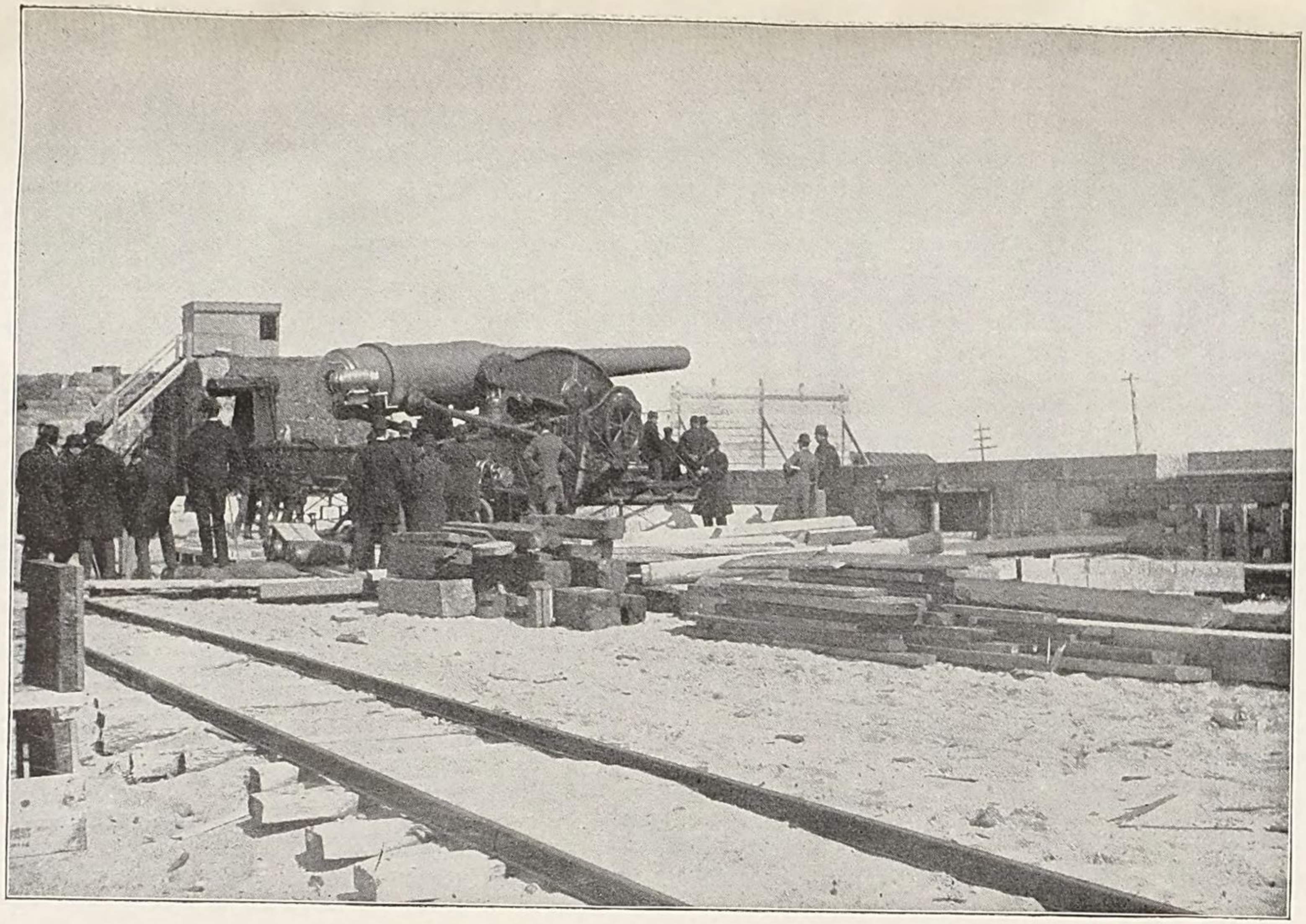

Elevation
15°
5°
F
Reflectors
L
E
O
R
S
J
P
Q
Training Gear
Elevating Gear
B
A
I
B
K
C
H
U
D
M
Part Section to shew
two rollers ring & combined
racer Rack & Clip ring

6 inch 5 ton B.L. Armstrong Gun,

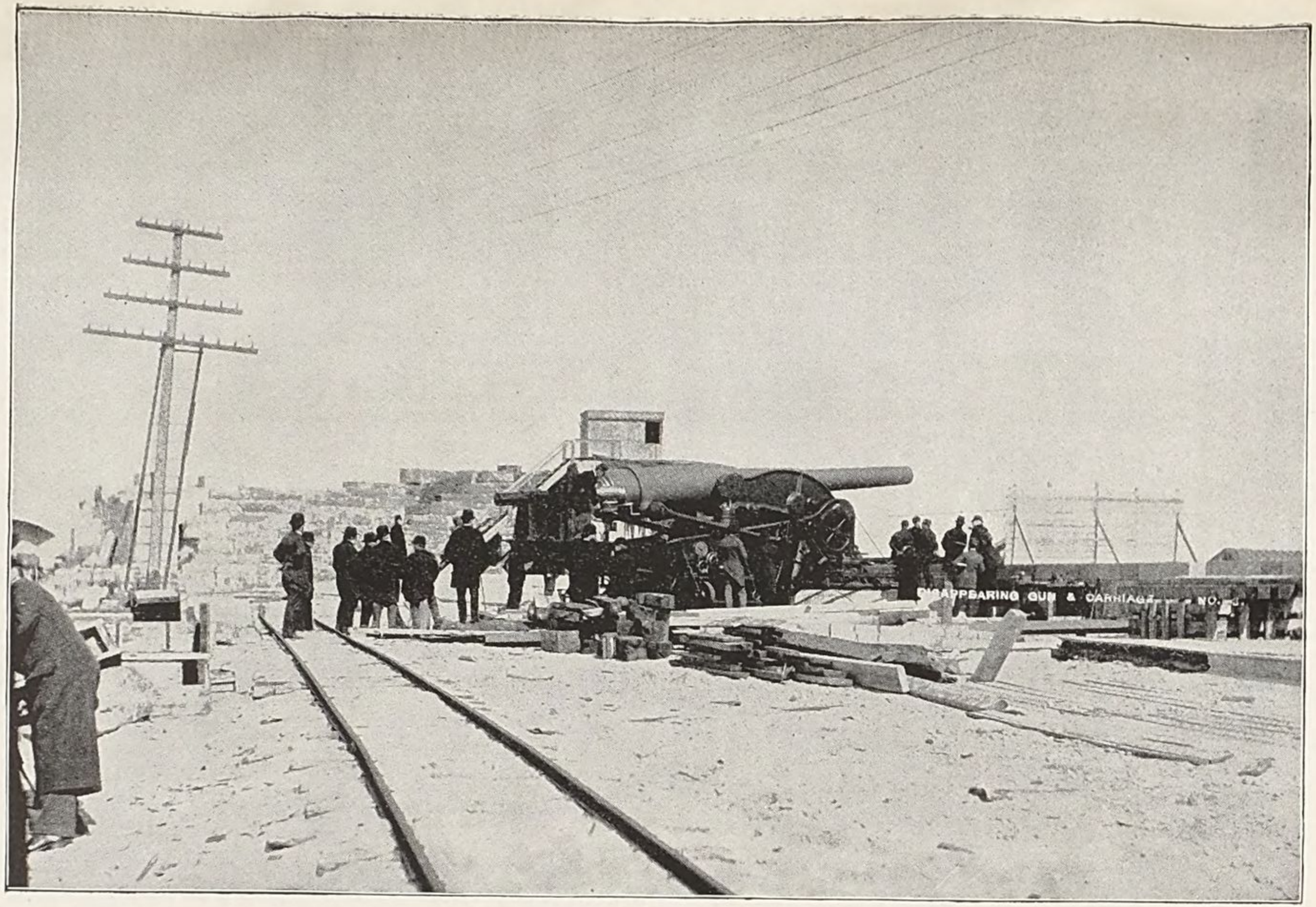
Mounted on Hydro-pneumatic Disappearing Carriage



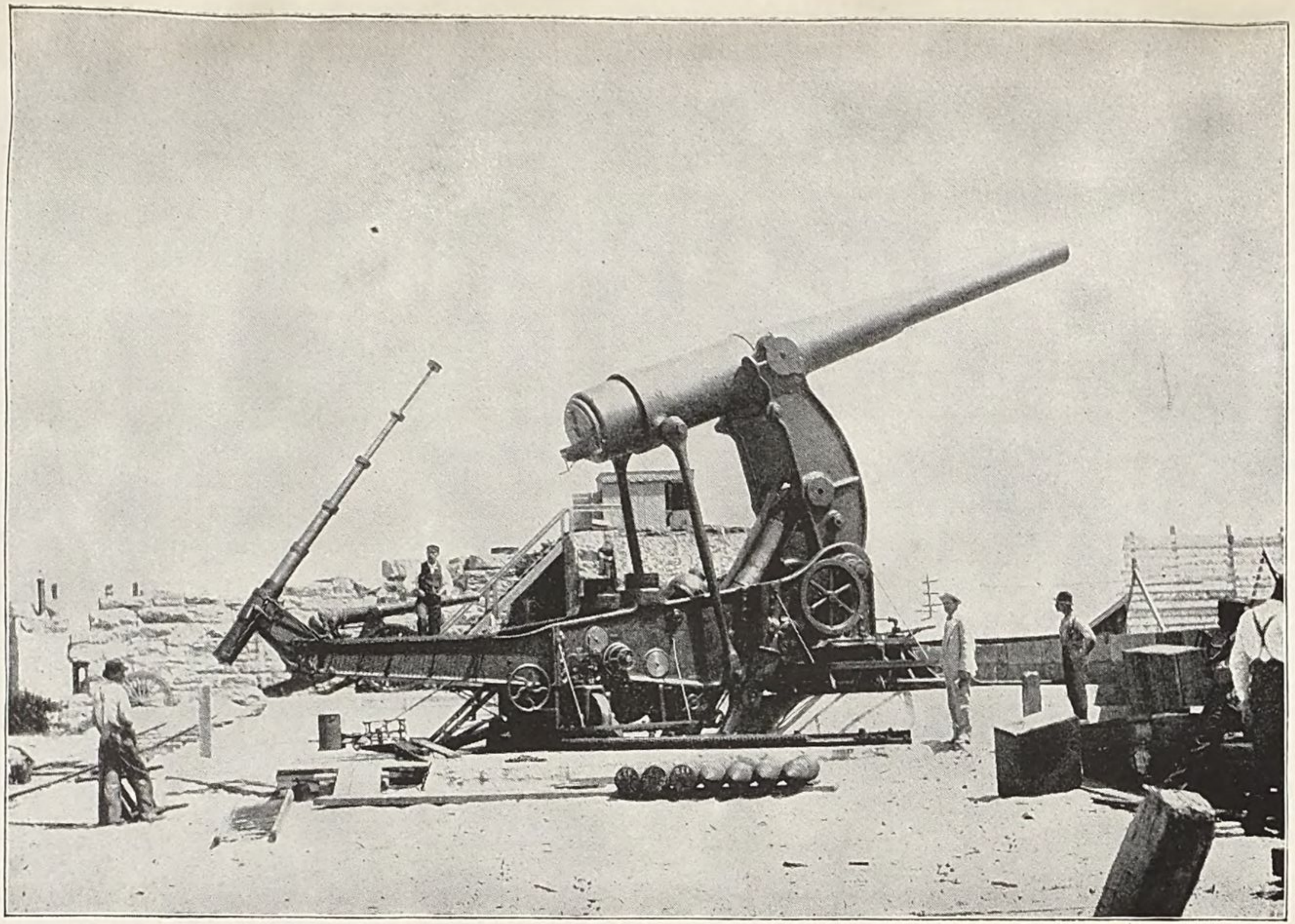




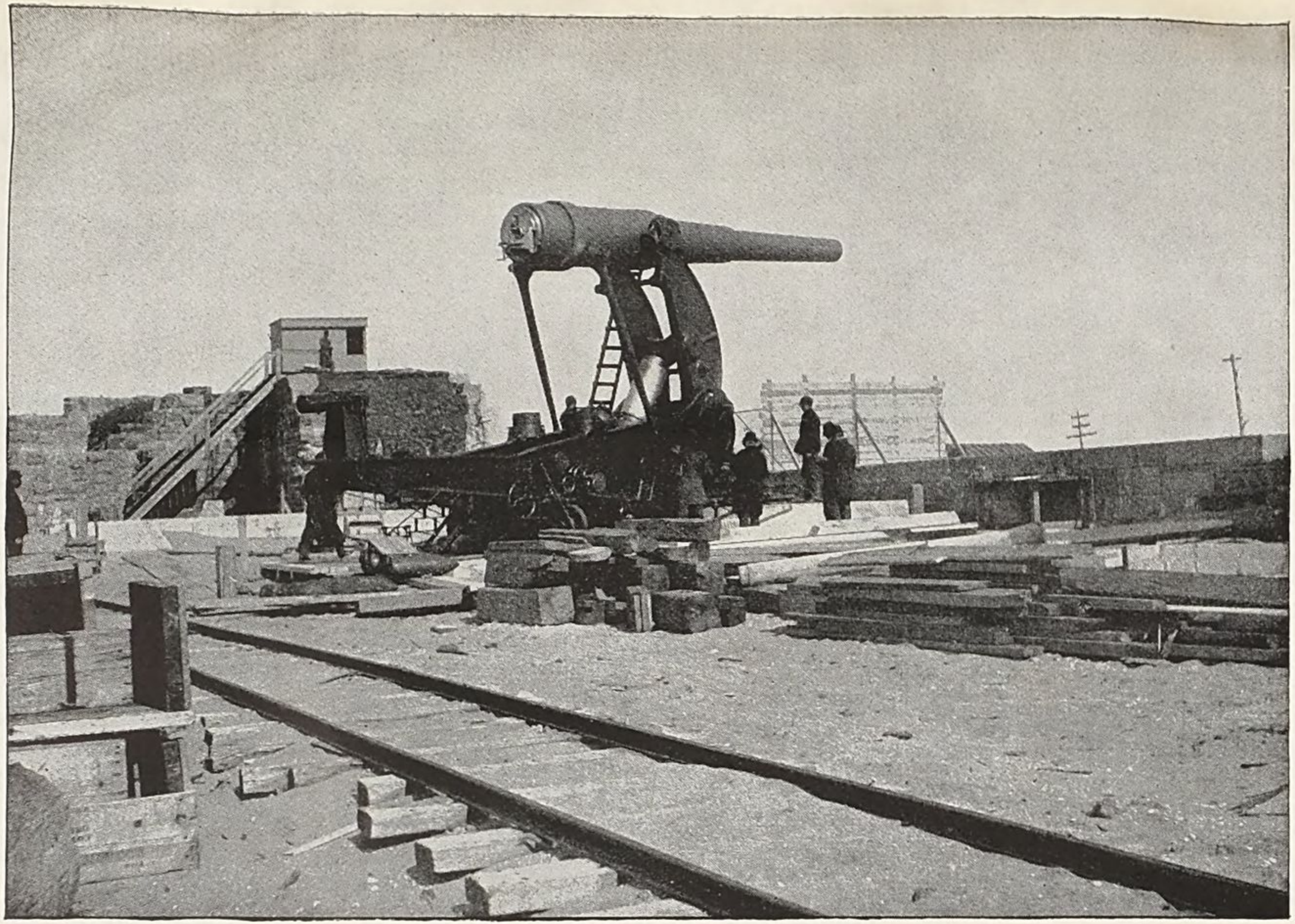
1. Pneumatic Carriage—10″ B. L. R. Loading Position.



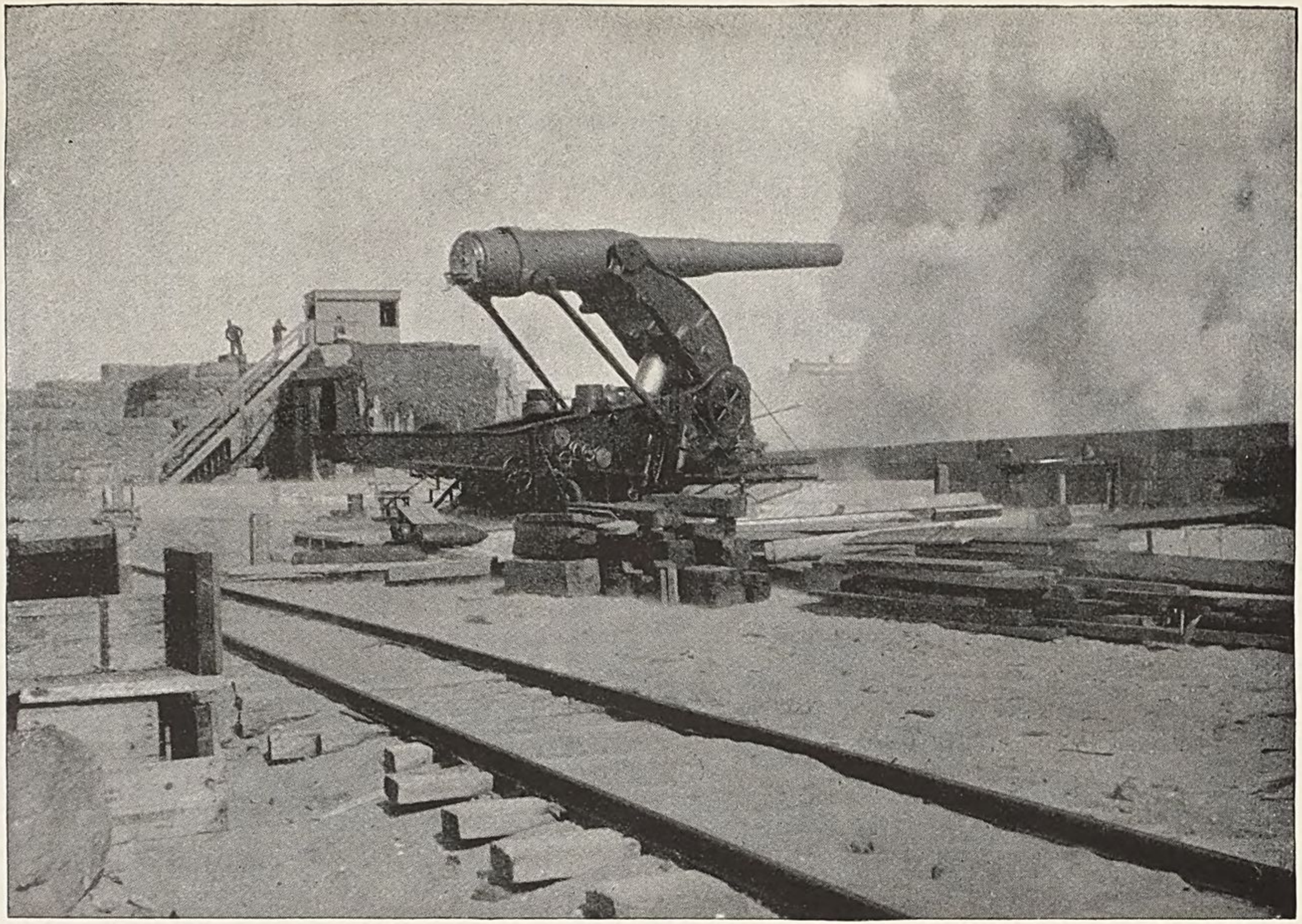
2. Pneumatic Carriage—10″ B. L. R. Loading Position.



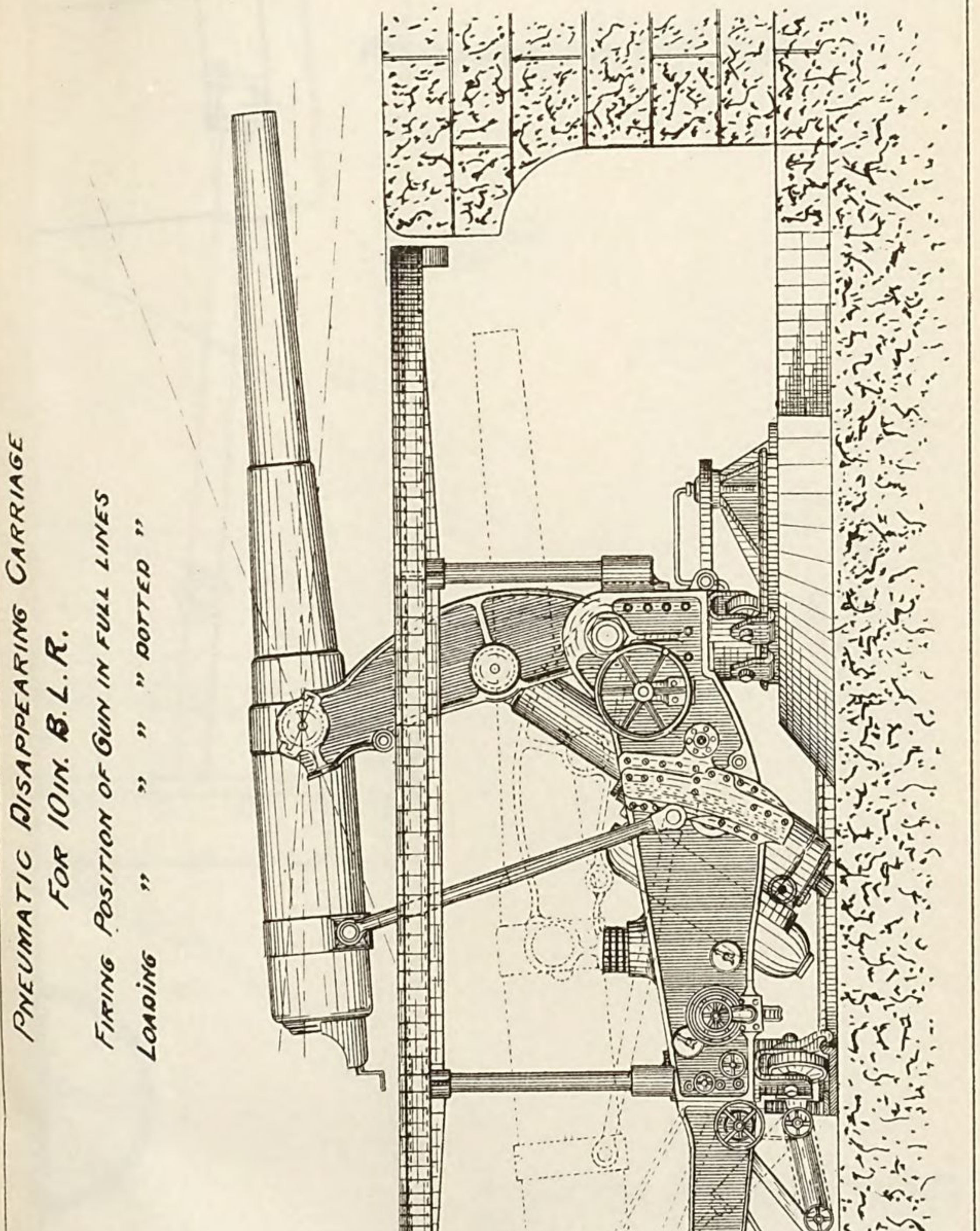
3. Pneumatic Carriage—10″ B. L. R. Gun elevated 20°. Rammer extended to show Action.



4. Pneumatic Carriage—10″ B. L. R. Firing Position. 0° Elevation.



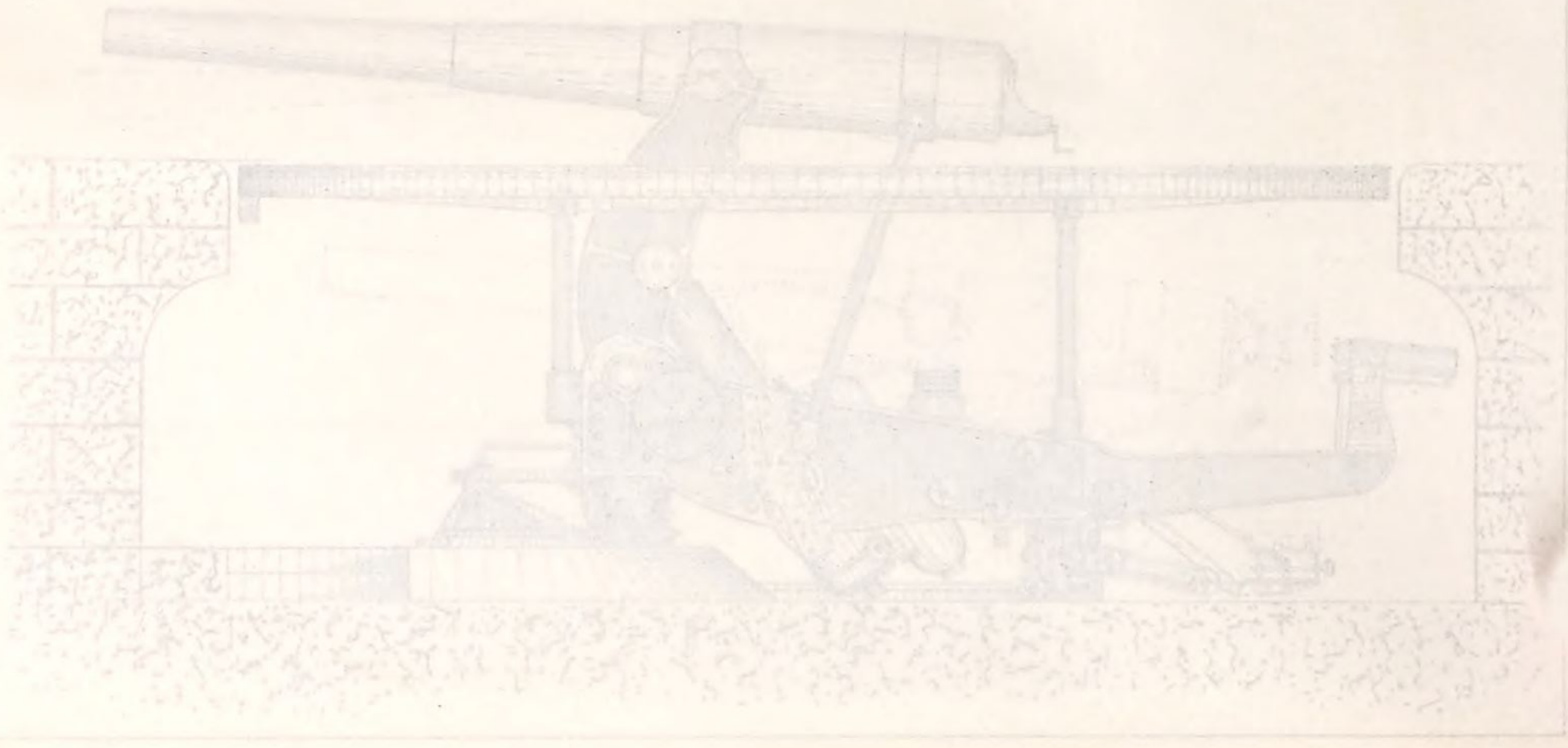
5. Pneumatic Carriage—10″ B. L. R. "Fire!"



PNEUMATIC DISAPPEARING CARRIAGE
FOR 10IN. B.L.R.

FIRING POSITION OF GUN IN FULL LINES
" " " DOTTED "
LOADING " "

Ord 53 2



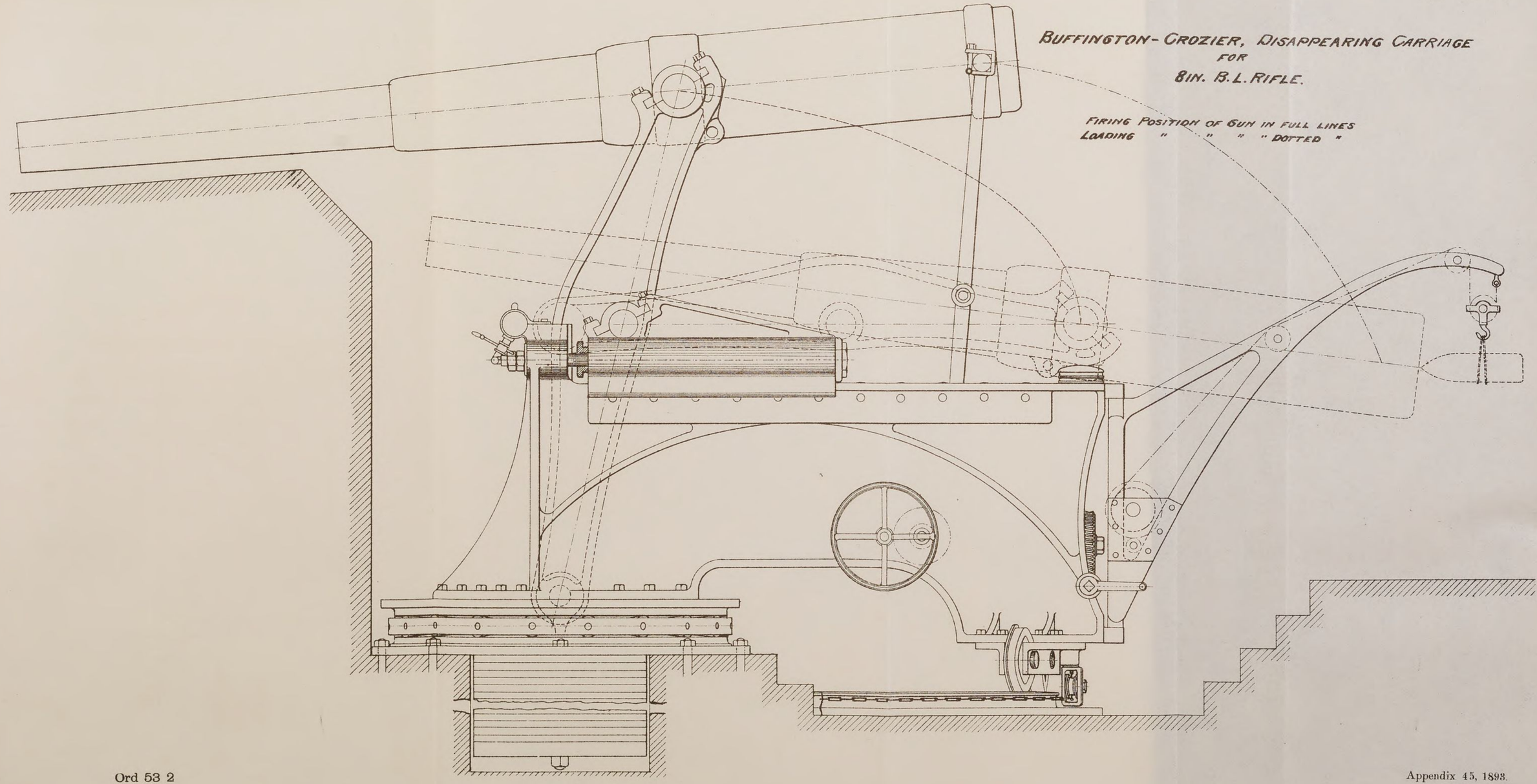
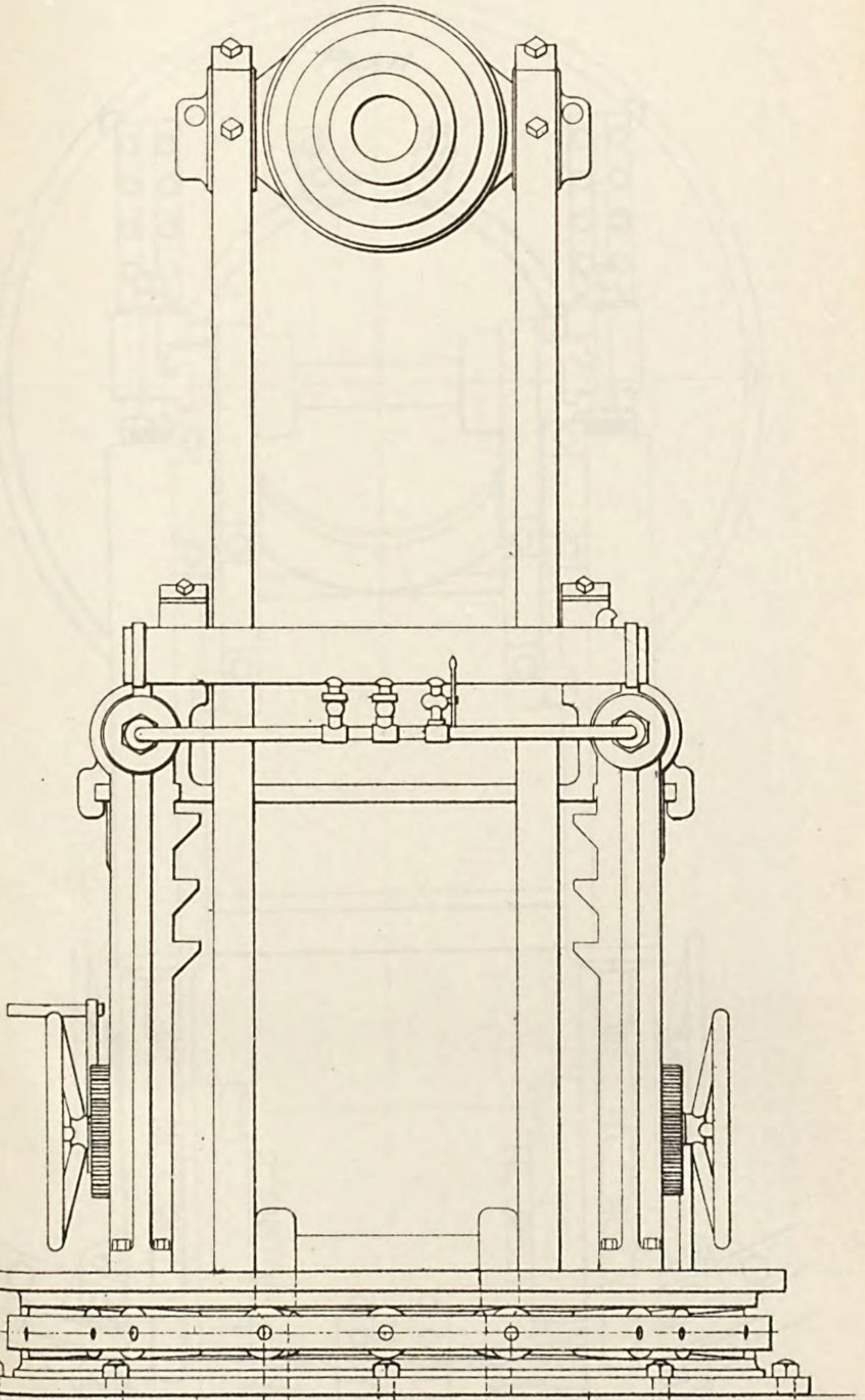

BUFFINGTON-CROZIER, DISAPPEARING CARRIAGE
FOR
8IN. B.L. RIFLE.
FIRING POSITION OF GUN IN FULL LINES
LOADING " " " " DOTTED "

PLATE VII.

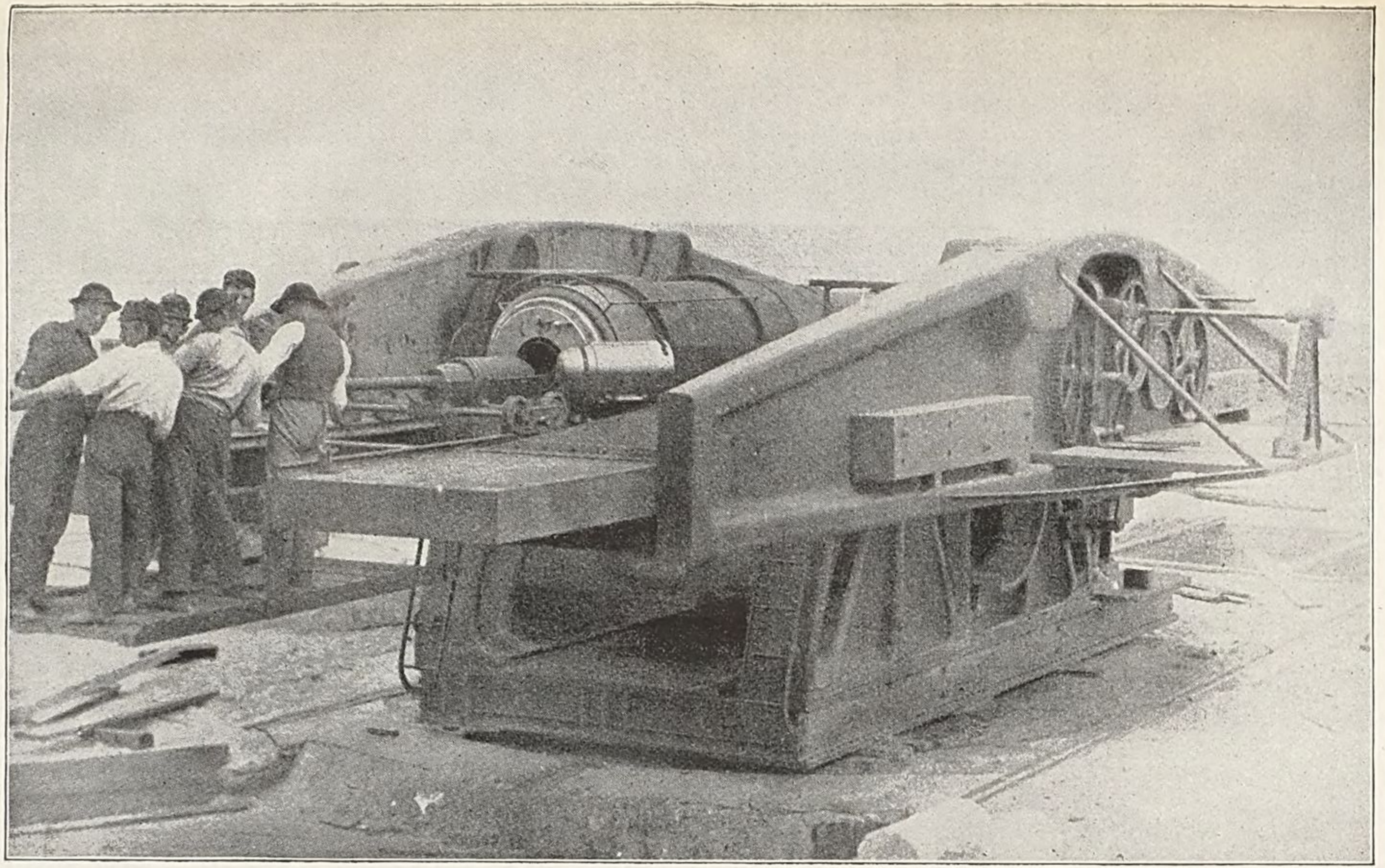
BUFFINGTON-CROZIER CARRIAGE FOR 8IN. B. L. RIFLE.



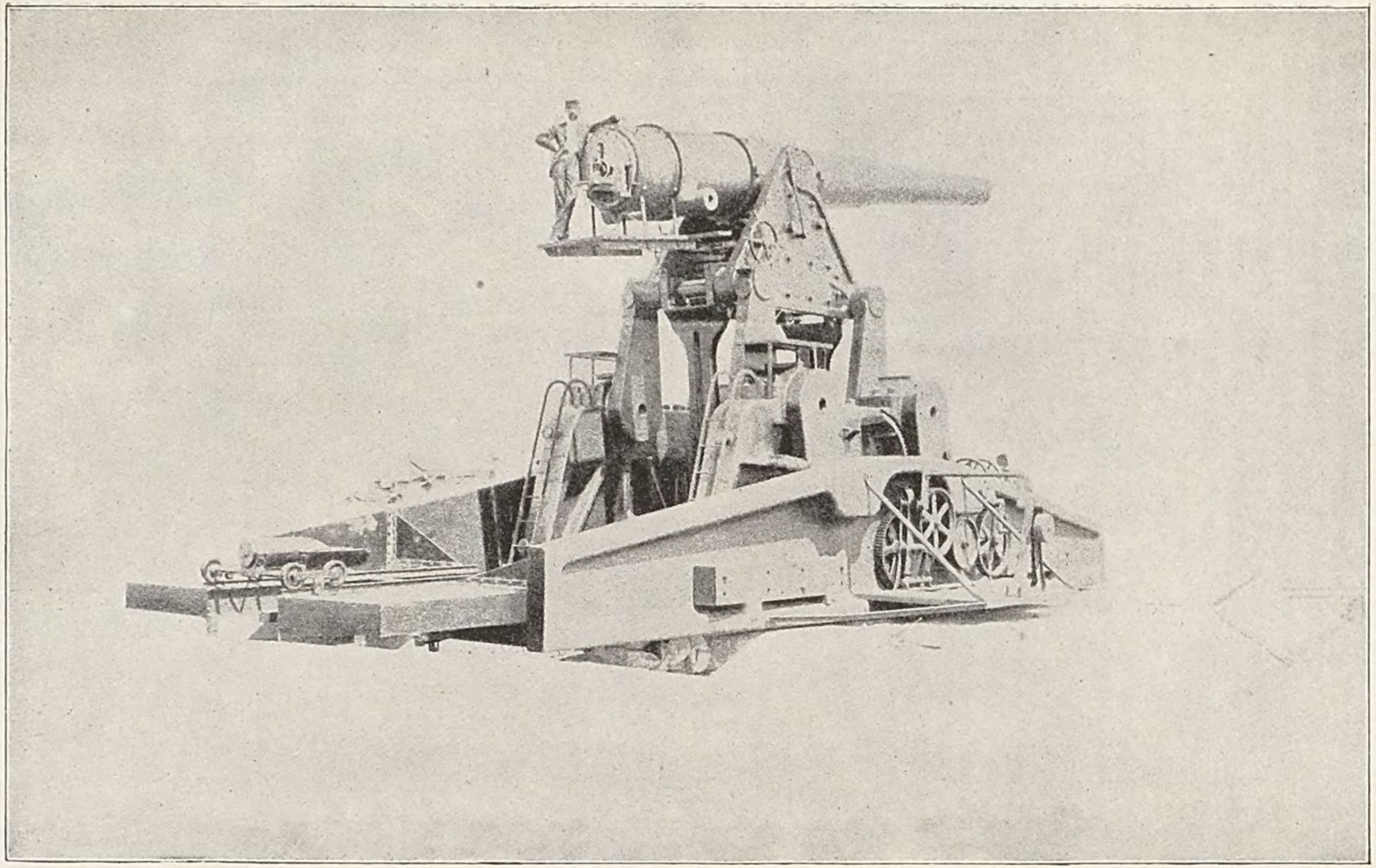
FRONT ELEVATION

Ord 53 2

Appendix 45, 1893.

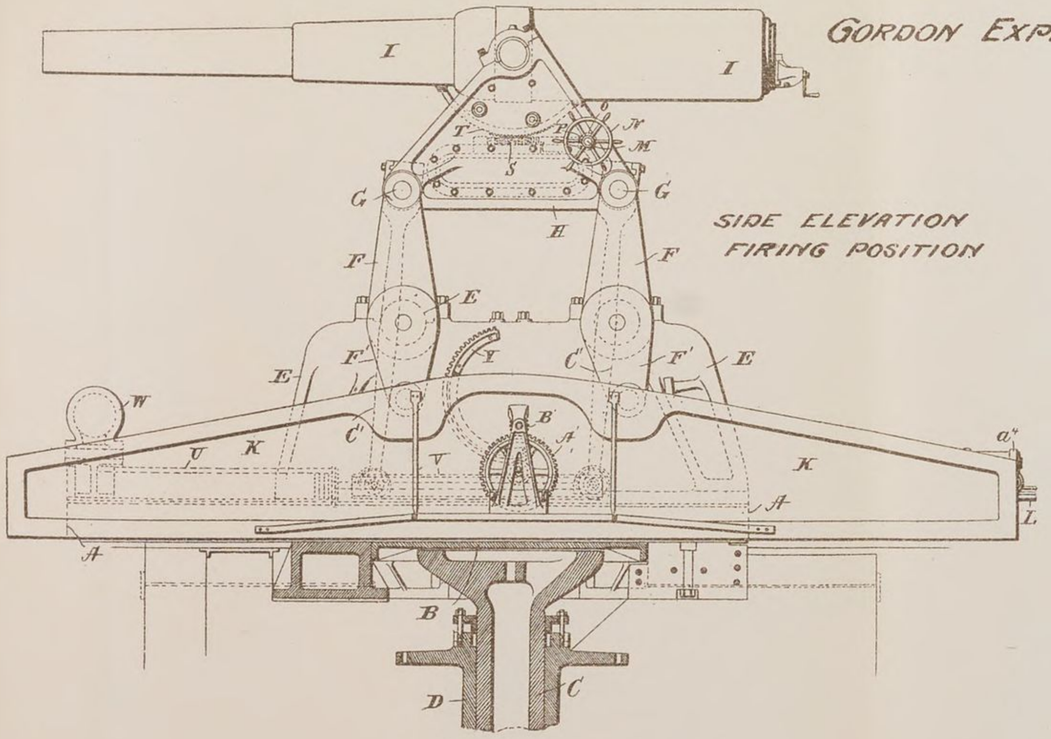


1. Gordon Disappearing Carriage—10″ B. L. R. Loading Position.

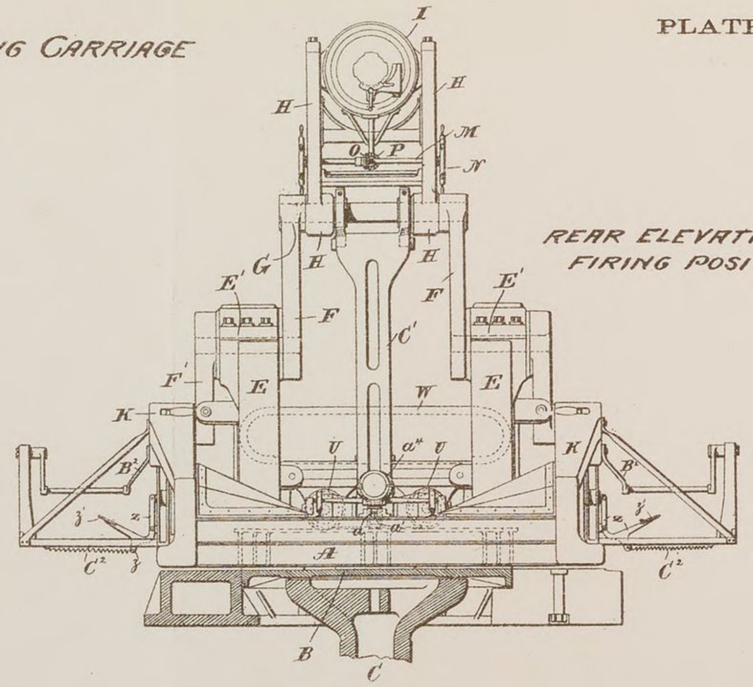


2. Gordon Disappearing Carriage—10″ B. L. R. Firing Position.

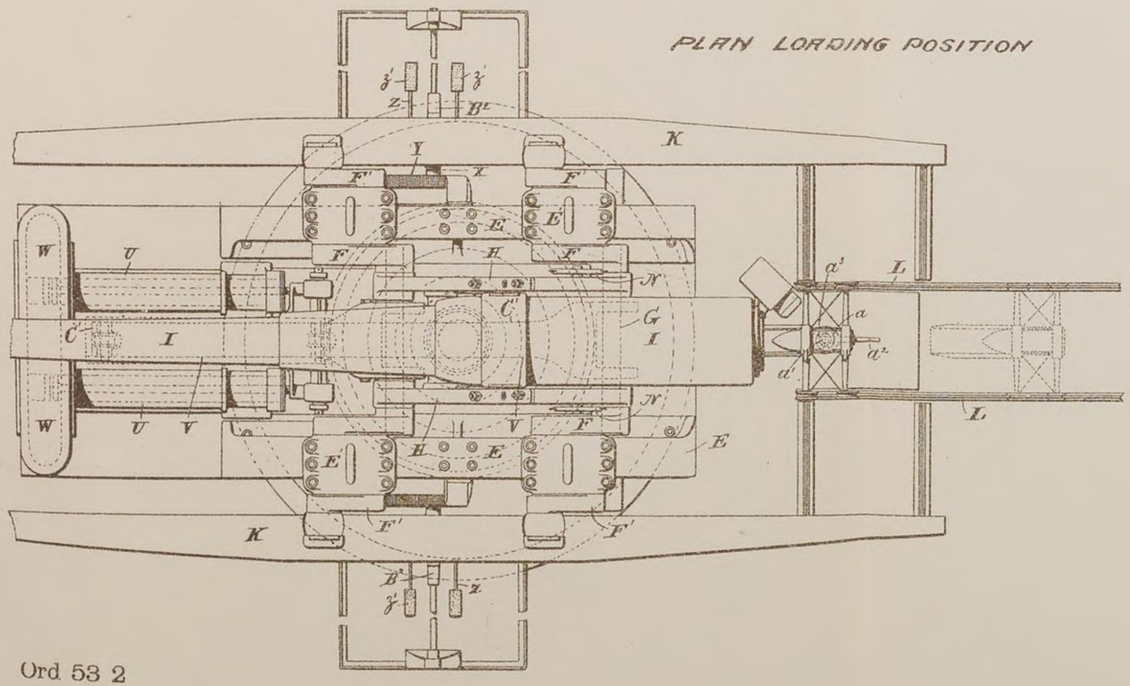
GORDON EXPERIMENTAL DISAPPEARING CARRIAGE FOR 10 IN. B.L. RIFLE



SIDE ELEVATION
FIRING POSITION

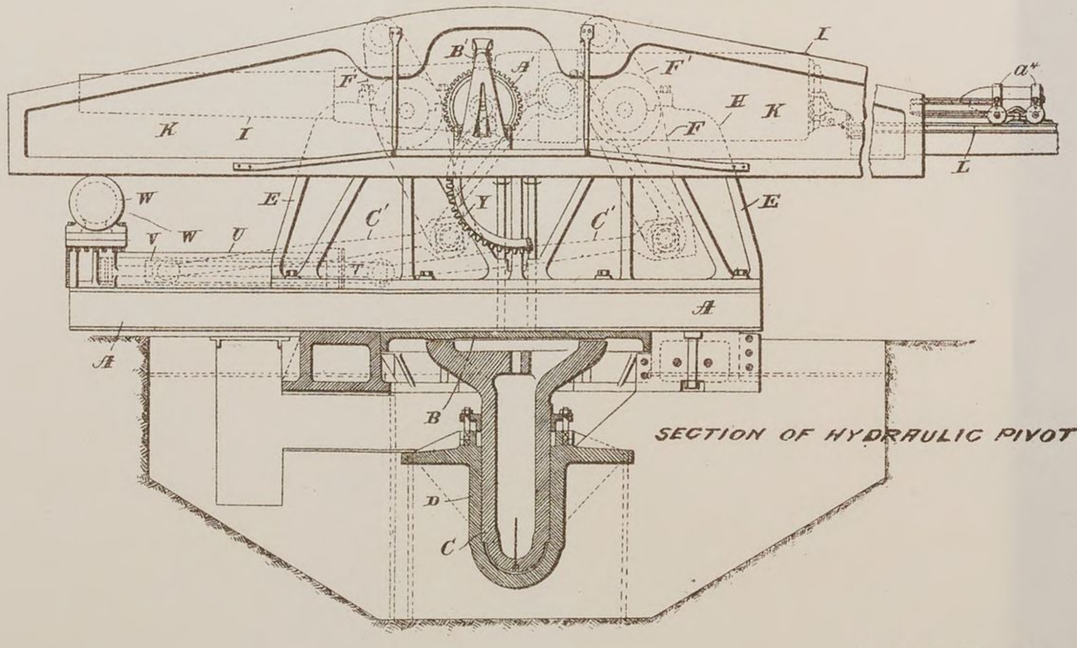


REAR ELEVATION
FIRING POSITION



PLAN LOADING POSITION

SIDE ELEVATION, LOADING POSITION



SECTION OF HYDRAULIC PIVOT

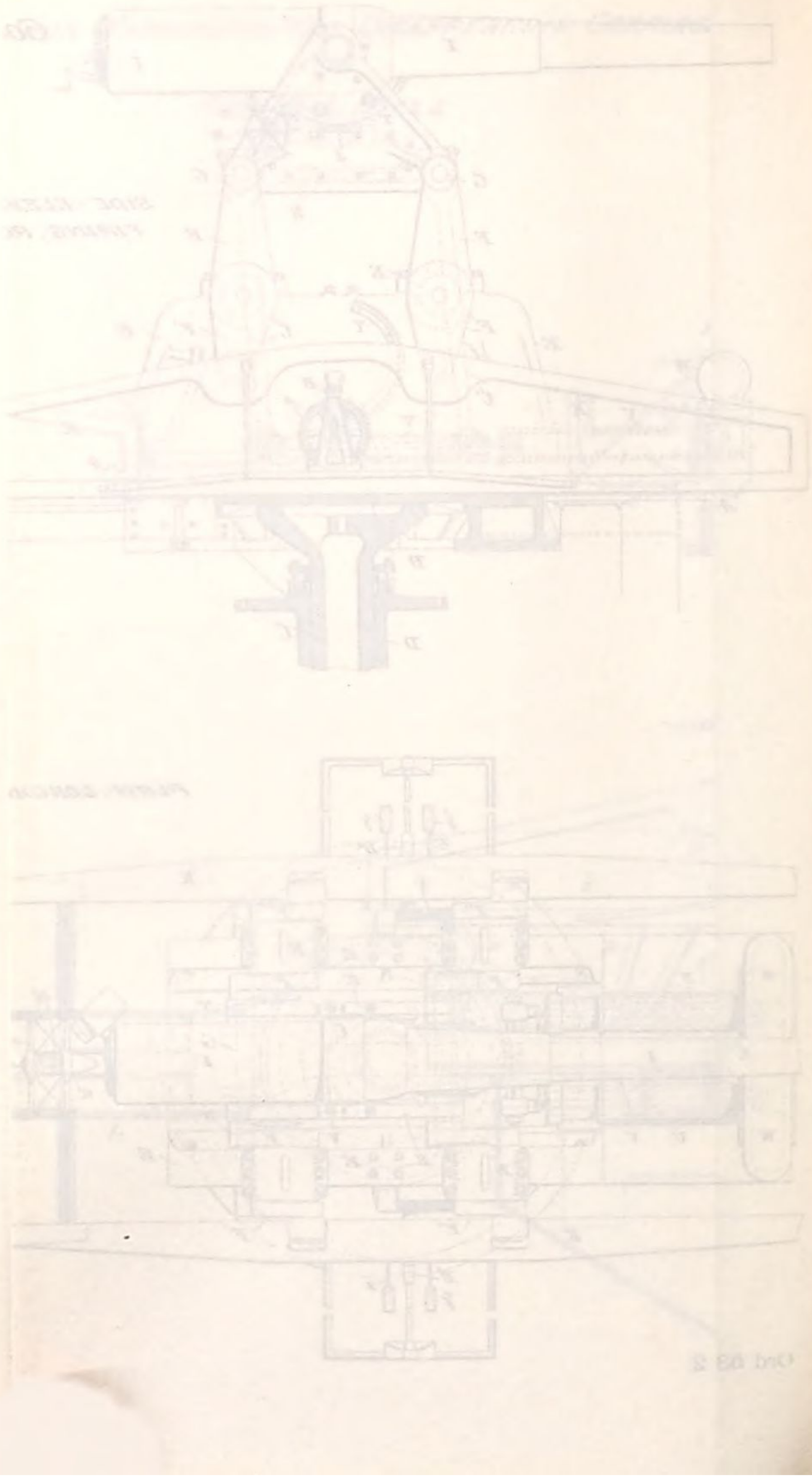
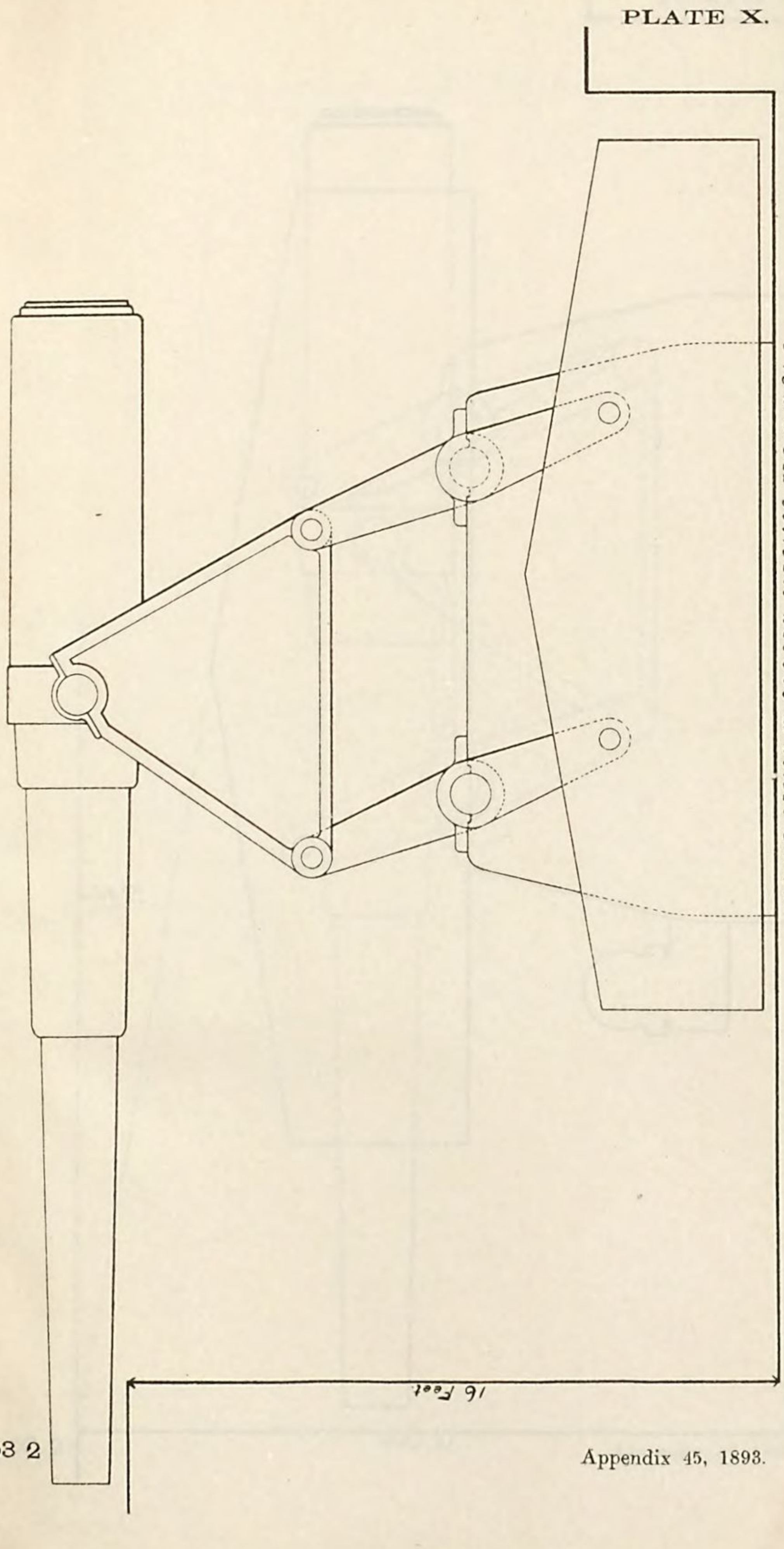


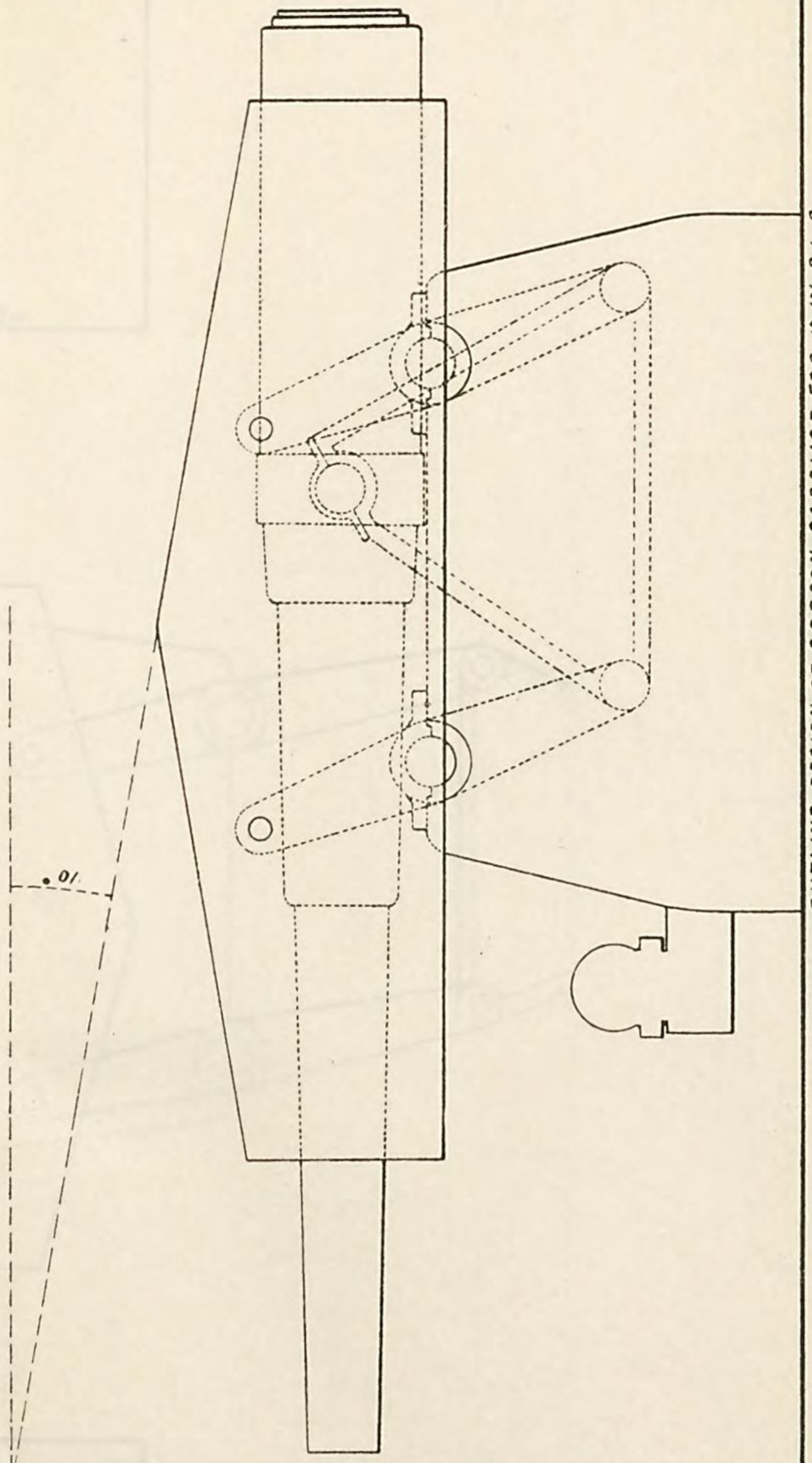
PLATE X.



OUTLINE DESIGN OF GORDON CARRIAGE FOR 10-IN. B.L.R.
FIRING POSITION.

Ord 53 2

PLATE XI.



Ord 53 2

Appendix 45 1893.

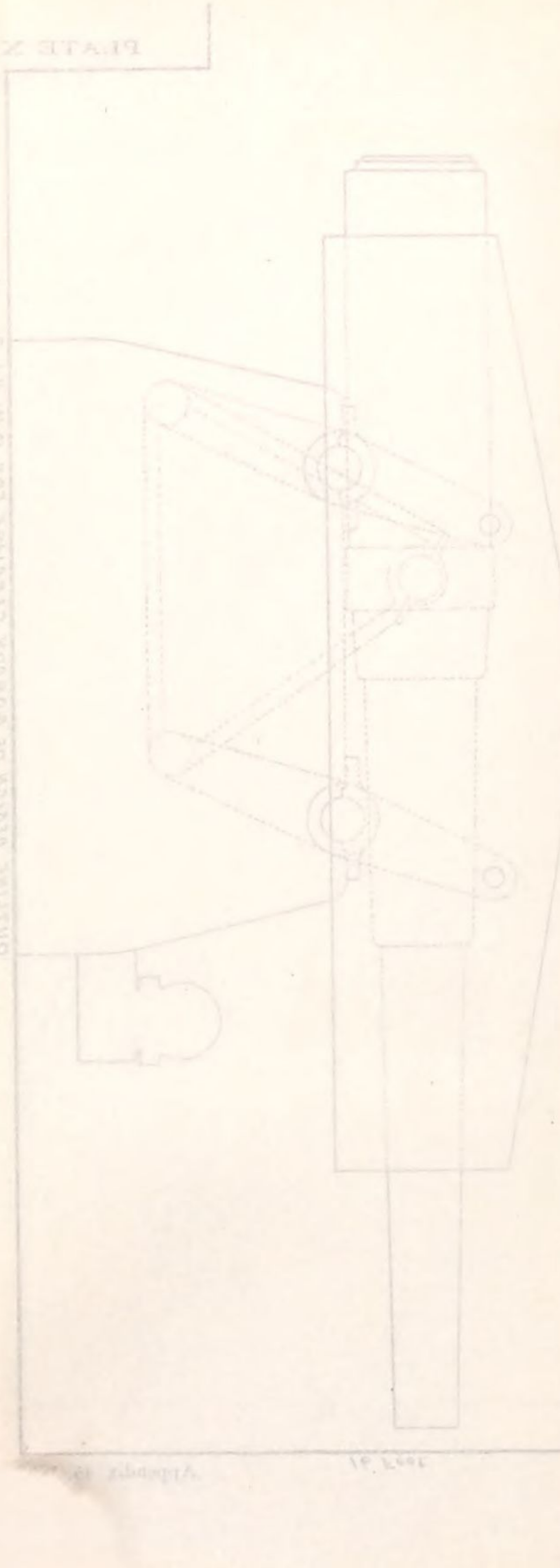
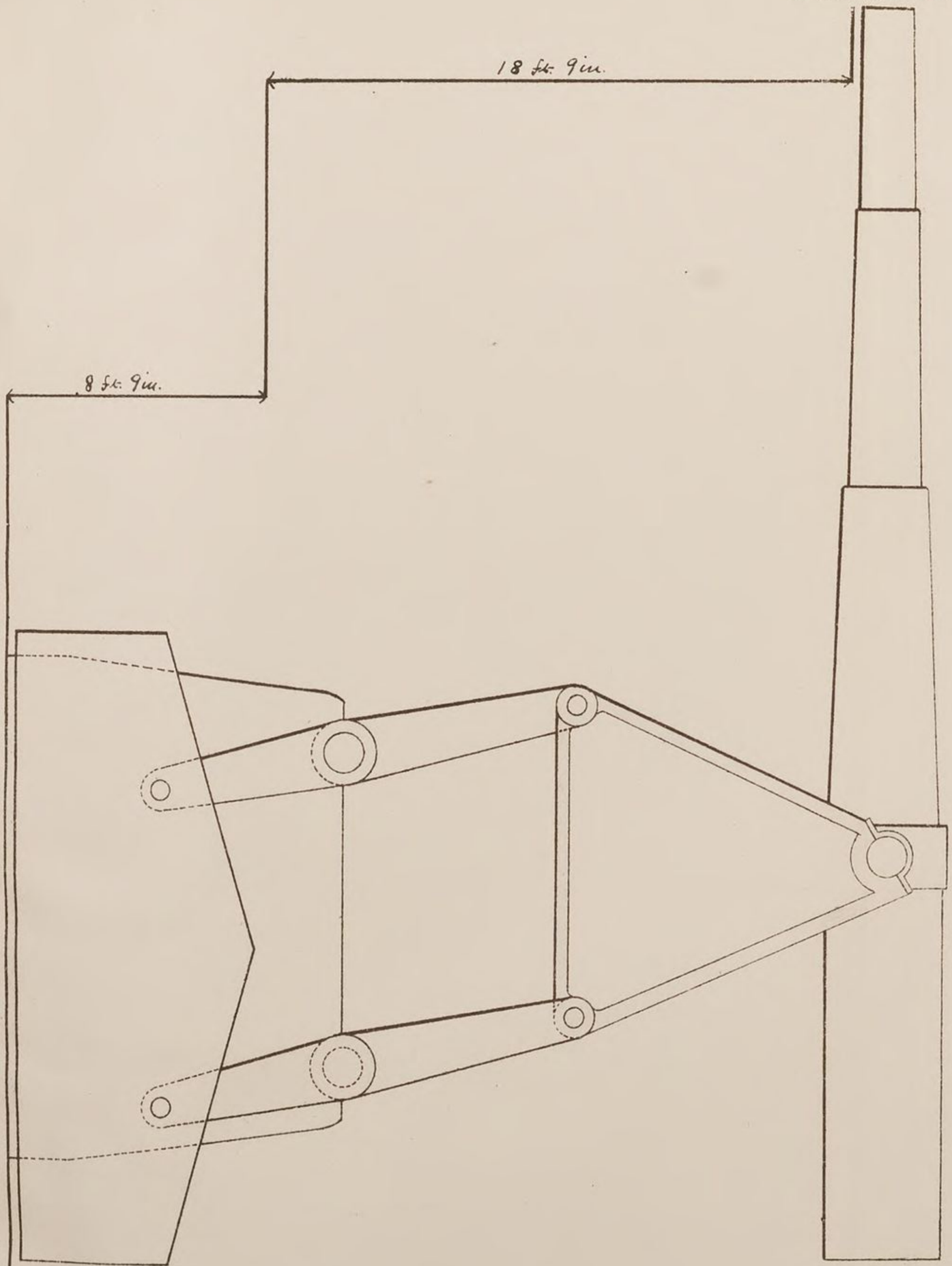


PLATE XII.



OUTLINE DESIGN OF GORDON CARRIAGE FOR 12-IN. B. L. R.
FIRING POSITION.

Ord 53 2

Appendix 45 1893.

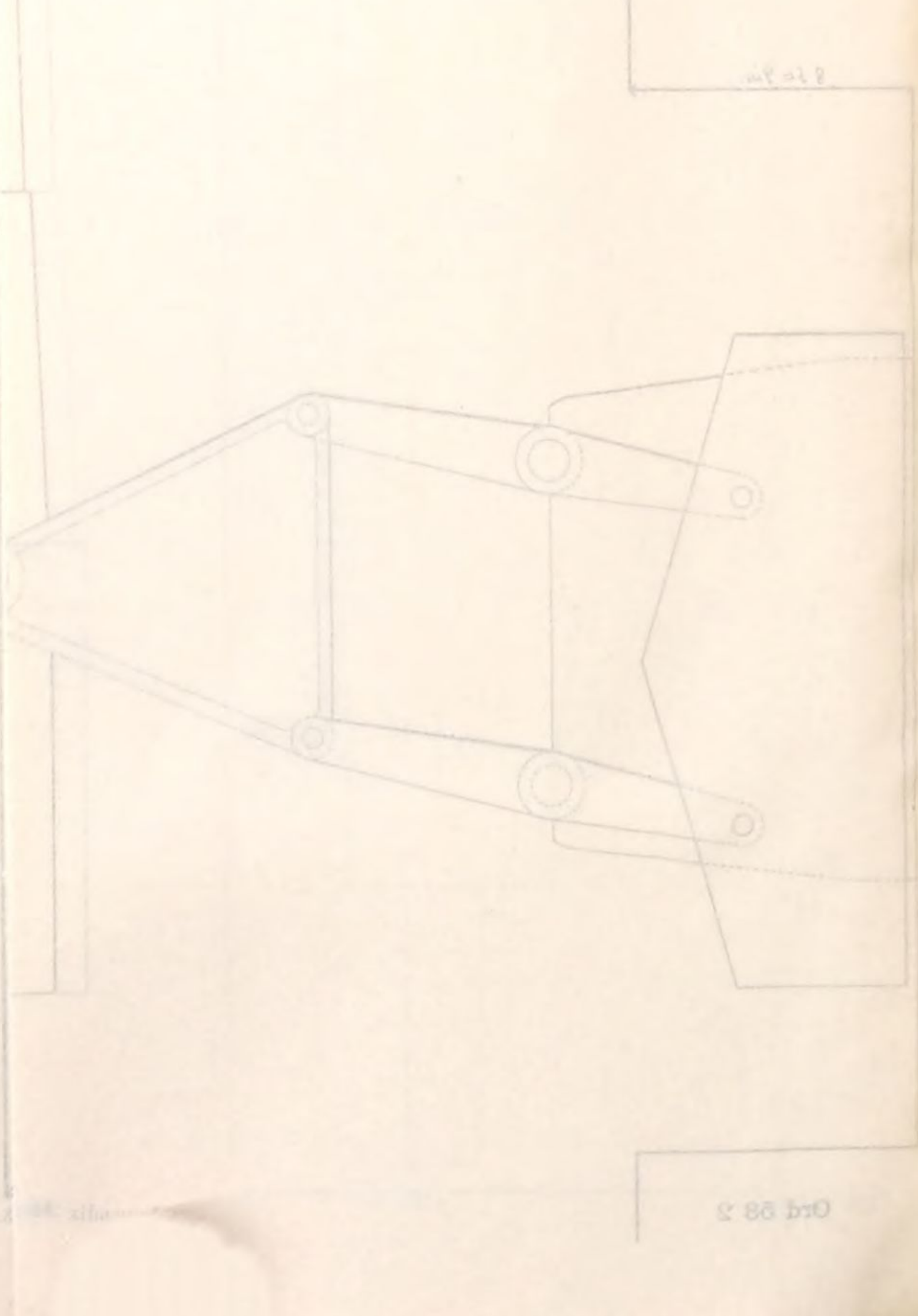
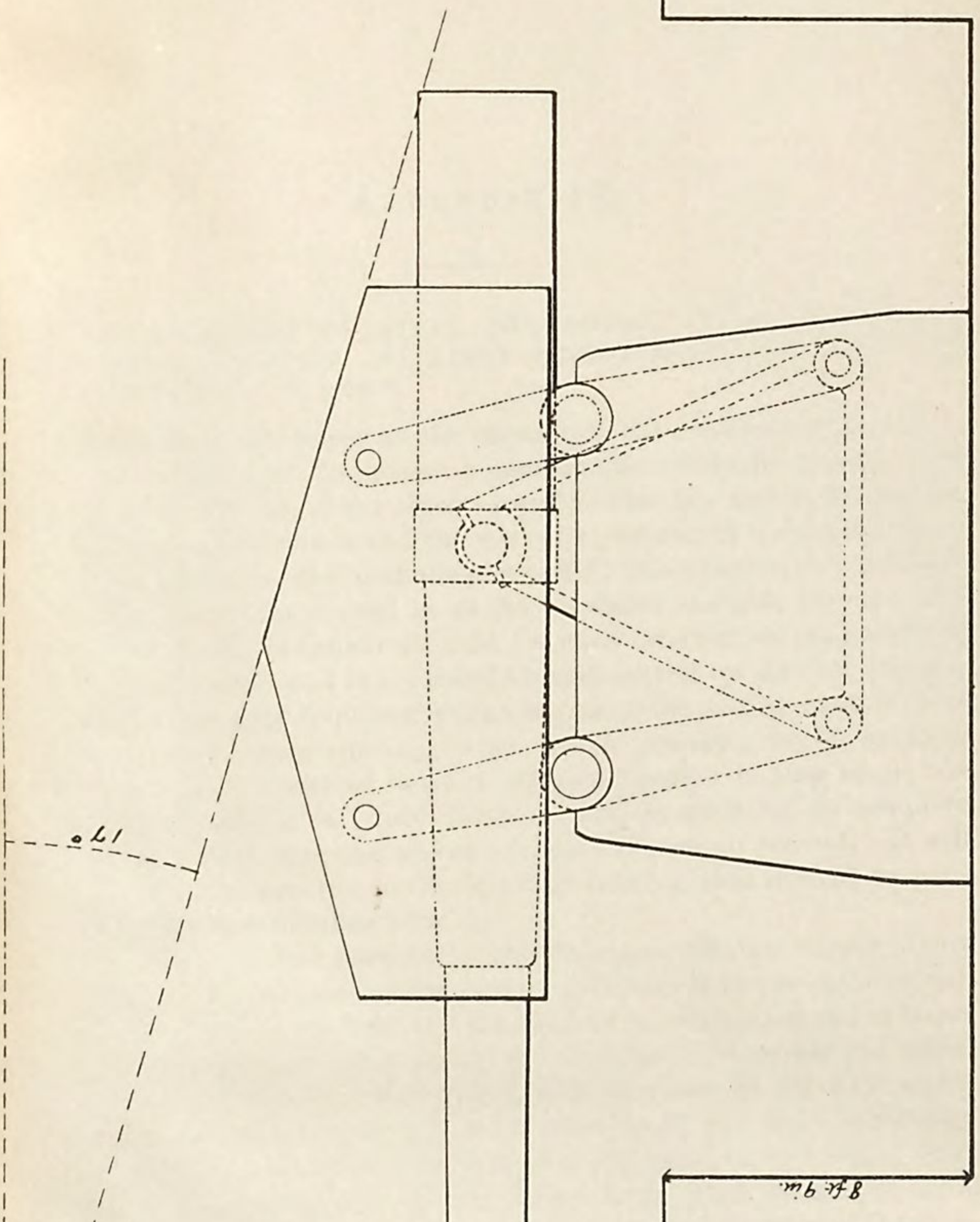
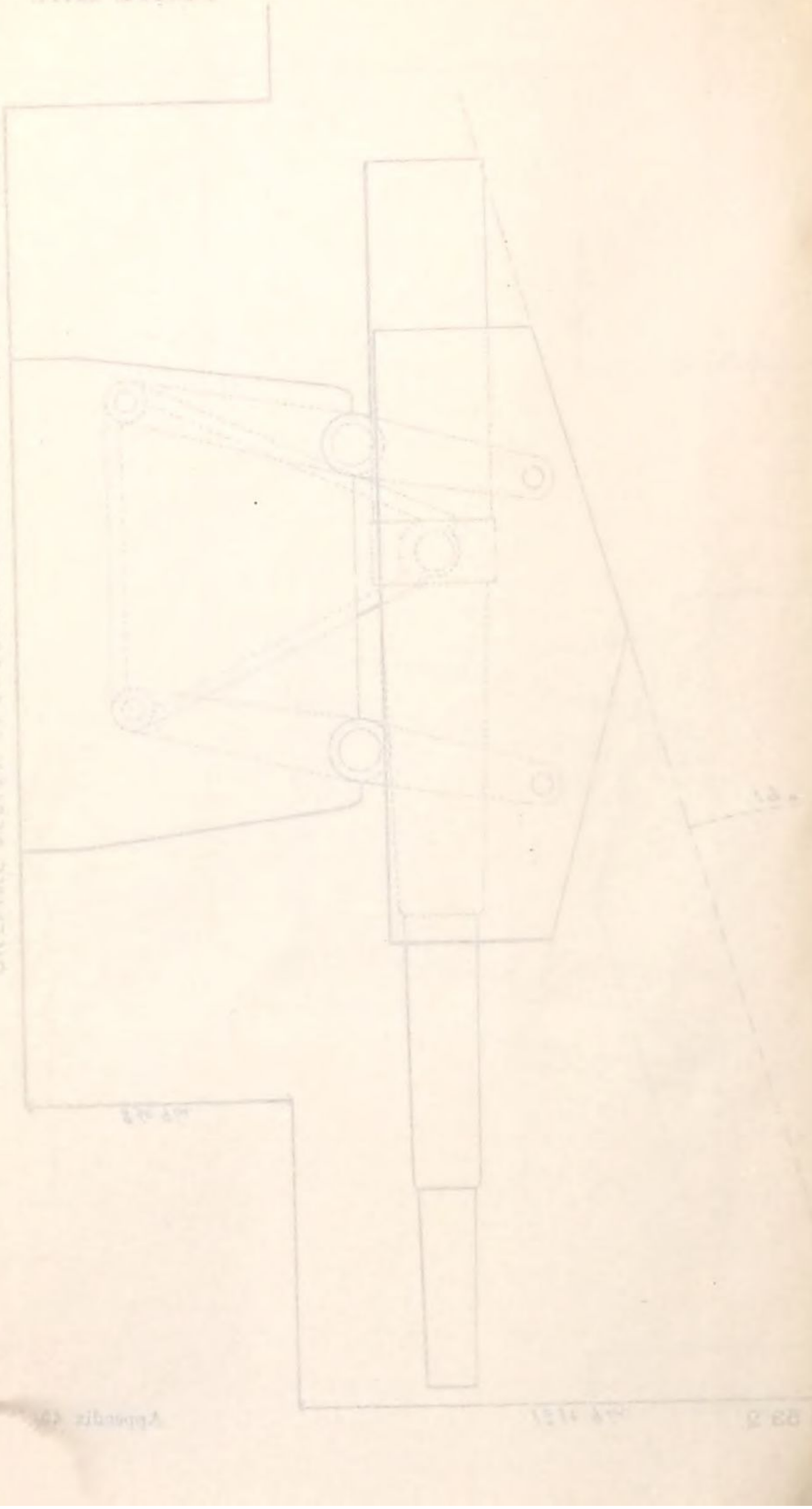


PLATE XIII.



Ord 53 2

Appendix 45, 1893.



APPENDIX 46.

THE MANUFACTURE OF STEEL FOR MODERN GUNS AND OTHER ORDNANCE PURPOSES. BY LIEUT. SIDNEY E. STUART, ORDNANCE DEPARTMENT, U. S. ARMY.

In preparing this paper at the request of the chairman of the division the aim has been to present a general view, from the standpoint of the ordnance official, of the objects sought to be obtained in this branch of ordnance manufacture and the methods pursued in obtaining them. It does not describe the methods pursued by manufacturers to produce the required results, except in so far as these methods may be prescribed by the Government officials, for such information is properly of a private character and is regarded as confidential by the Government inspectors who may acquire it in the course of the performance of their duty. It omits, consequently, what would probably be of greatest interest to the majority of those to whose attention it may come, but will, nevertheless, it is hoped, have a value in assisting to complete the picture which it is the object of this division to present. It will treat only of the practice in this country, leaving that abroad to pens that may be more familiar with it.

The general method pursued by the ordnance officials of our Army and Navy to secure steel of the desired qualities is to prescribe in general terms the kind of steel and the method of fabrication and of treatment, and in more precise ones the physical qualities which the metal must possess at the time of delivery, and to secure by personal supervision of an inspector accuracy in the tests made and such uniformity throughout the manufacture as to insure that the test specimens shall be fairly representative of the metal delivered. They do not prescribe the details of manufacture, but leave them to the initiative of the manufacturers, thus enabling these latter to select the method best suited to the means at their command and securing the advantages of private initiative in developing new and improved methods of manufacture. The personal supervision of the inspector is, however, generally greater and more exacting than is usually employed between private firms, a condition that is made necessary by the fact that the specifications generally call for greater care and cost in manufacture and higher qual-

ities in the product than is often demanded by private firms, and further justified by the fact that the Government is not so free as they are to make the award of future contracts depend on the character of the work done under past ones.

I shall take up separately the manufacture of steel for guns, for carriages, for projectiles, and for armor.

GUN STEEL.

In the fabrication of built-up cannon a much smaller factor of safety is employed than for other structures, in fact, an allowance of a factor of 2 in passing from a static load to a moving one would reduce the factor of safety below unity, for no cannon have an elastic resistance to static stress twice as great as the ordinary service stress. It is, therefore, necessary that complete reliance may be placed in each piece assembled into the gun, a condition which demands a large amount of testing and inspection. The specifications for the securing of this result are, in brief, that the parts must be sound, of open-hearth steel, forged, oil-hardened, and subsequently annealed, and show certain physical qualities in tensile specimens cut from the pieces themselves after their final treatment. Let us now consider these various requirements separately.

Metal.—Open-hearth steel is required, as it has been found that it produces a satisfactory product, and it is feared that Bessemer metal would not show such uniformity and soundness, and, moreover, the original cost of the metal is so small in comparison with the cost of the work put on it that it is not believed that even those manufactures professing the greatest faith in Bessemer steel would preferably use it for work required to pass the tests specified for gun-forgings. It is required to be cast in suitable ingots from which, if cast in the ordinary manner, about 30 per cent must be discarded from the top and 5 per cent from the bottom, but for ingots formed in any special manner, as, for example, with "fluid compression," a special determination of the suitable discard is to be made, and any special allowance would generally be coupled with some condition as to boring in the ingot state. The choice of mixture, composition, and other conditions not mentioned above is left to the manufacturers.

Forging.—The only conditions imposed on this process are that all pieces must be wrought as closely as practicable to the final dimensions and that tubes and jackets must receive a specified amount of reduction of cross section of the ingot, to about one-fourth for tubes and one-third for jackets, or if bored ingots are used, the wall must be reduced at least to one-half its original thickness. This operation is an object of inspection with a view to securing uniformity in heating and working between the middle parts of the piece and the ends from which the tests are to be taken. Rolling may be employed instead of forging whenever practicable.

Treatment.—Annealing after forging may be required by the inspector, but is habitually required only for the more important pieces, such as tubes and jackets.

Hardening in oil is required, not only because it improves the quality of the best forged metal by, say, one-eighth to one-fourth, but also because it serves as a corrective of any unevenness of quality that may exist due to any difference in the forging of the tested and untested parts of the piece. It has also the not inconsiderable merit of furnishing a means, in connection with the subsequent annealing, of placing the metal in the right position in the scale of hardness, so as not to be either too weak or too brittle, and so of admitting a considerable variation in the chemical composition from ingot to ingot or heat to heat. The temperature of this operation is not prescribed, but the process is, in the Army at least, carefully inspected in order to secure uniformity throughout each piece.

The subsequent annealing is conducted with similar conditions of initiative and inspection, and its temperature is so determined as to produce the correct balance between the opposed qualities of strength and ductility. Should the subsequent test show the treatment to have been unsuccessful in producing the required qualities, but indicate a probability that further treatment would do so, retreatment is allowed, to be conducted under the same conditions as at first. So effective is good treatment that it rarely fails to correct defective forging, if not positively bad, or a considerable divergence from the chemical composition best calculated to the production of the qualities required. A most valuable effect of the last annealing is that all internal strains, from whatever cause resulting, are removed thereby, so that the pieces, when ready to be assembled in the gun, are in the neutral condition best conducive to their strength and also necessary to their proper effect in producing the desired initial tension in the built-up structure. Direct experiments and other experience have demonstrated that, at the temperature currently employed for the final annealing, the internal strains, which exist in a high degree after the hardening process, are entirely relieved in this operation.

Physical tests.—The requirements as to physical qualities include tensile strength, elastic limit, and elongation, and for tubes and jackets, contraction of area. The specimens are cylindrical, 2, 3, or 4 inches long between gauge marks, depending on the size of the piece from which they are taken, and have an area of cross section of one-fifth of a square inch for the first and one-fourth of a square inch for the last two sizes. They are taken from the pieces themselves, from both ends if more than 50 inches long, and are always "tangential," that is, their axes are tangential to a circle whose plane is perpendicular to the axis of the gun with the piece in position, so that they test the metal in its actual state and in the direction of the stress which it is particularly intended to resist. They are also placed at a distance from the end of

the piece in order to avoid the local influence of the cooling from the end face, and at various positions in the thickness of its wall to more thoroughly search the metal and test the effect of the treatment.

The qualities required by the Army are about as follows:

	Tubes.	Jackets.	Hoops.	Breech-blocks.
Elastic limit.....pounds per square inch..	42,000	45,009	53,000	45,060
Tensile strength.....do....	78,000	85,000	93,000	35,000
Elongation; equivalent per cent in 3-inch specimens.....	17	16	15	16
Contraction of area.....per cent..	30	27	.....	.....

The Navy requires about 8,000 pounds per square inch less elastic limit and tensile strength, and also somewhat less elongation and contraction of area. They are now, however, having an experimental gun made of nickel steel for which they require physical qualities equal to those above tabulated.

It has been shown by a set of experiments carefully conducted by the Ordnance Department of the Army that the modulus of elasticity and the elastic limit, as determined from the test specimens cut from the pieces, hold good for the pieces themselves when assembled into the gun. While this condition serves to give confidence in the performance of the built-up gun, it also indicates, in connection with the small factor of safety used in these constructions, the propriety of a specially careful determination of these two qualities in the test specimens. But as the modulus of elasticity is found to be sensibly constant for all grades of gun steel this quality is not made a subject of requirement in the specifications for acceptance. The elastic limit, however, is made such a subject, and is the quality which is most carefully determined and on which most stress is placed; upon its value as thus determined from the acceptance tests is based its subsequent employment in the gun.

The tensile strength is considered of secondary importance, and the requirements in this respect are placed so low as never to cause the rejection on this account of a piece that shows the required elastic limit. The requirements as to elongation and contraction are fixed sufficiently high to secure a good degree of ductility or non-brittleness in the metal, and are also so placed with respect to the elastic limit and tensile strength as to secure that the steel which possesses all the requirements shall be very good metal in very good condition.

It is obvious that by raising the elastic limit the available strength of the gun could be increased or the weight diminished, while on the other hand a certain ductility or "softness" is necessary for safety against fracture from shock and concealed defects in the metal, the liability to both of which causes of failure increases with the "hardness" of the grade of steel. The actually adopted balance between these conflicting desiderata has been determined by a variety of causes.

Our methods of manufacture and treatment and the specifications governing them were based originally, some ten years ago, on the practice of the time, when a great and warrantable distrust of high steel was felt, as being liable to unexpected flaws, or, as it was said, treacherous, and they have not since then been materially altered. This treacherousness has, however, been greatly decreased with the advance of the art of steel manufacture; but owing to the small amount of experience that has been had in the use of large pieces of comparatively high grade, resulting partially from the comparative infrequency of a demand for them and partially from a discreet conservatism on the part of engineers that generally insists on retaining soft steel for such pieces when the use of a harder grade is urged by the manufacturers, the general recognition of the safety of harder steel has lagged far behind what the actual state of the art would warrant. The course of our ordnance constructors in not raising the requirements as to elastic limit during the last ten years has, therefore, been in accord with the general sentiment of engineers. Indeed, engineers of good standing have criticised the use of so high a steel as is actually employed. I think, however, that all who have become familiar with its manufacture and use agree that a considerable rise would be safe. For example, from an elastic limit of 42,000 pounds per square inch and 17 per cent elongation for tubes to 46,000 and 14 per cent, or 50,000 and 12 per cent, or from 53,000 and 15 per cent for hoops to 60,000 and 12 per cent, or 65,000 and 10 per cent.

But there have been two considerations that have been sufficient to deter ordnance constructors from making such a change: first, that they are well satisfied of the safety of their guns as they are, and to increase the ratio of the power of the gun to its weight would introduce considerable difficulties in the matter of controlling the recoil; and, second and more important, that erosion of the bore under the action of the powder gases is so serious at high pressures, especially in the larger calibers, and increases so much more rapidly than the pressure, as to practically establish a limit to the pressure allowable for service so long as steel is used for the inner tube. Thus the naval authorities are satisfied that 17 tons (long) per square inch would be a safe service pressure so far as the strength of their guns is concerned, but they nevertheless limit this pressure to 15 tons because of the erosion. So, also, no fears are entertained of the safety of the Army guns under a service pressure of 20 tons, but it is limited to 16½ tons for the same reason. And, moreover, such experiments as have been made seem to indicate that an increase in the hardness of the metal would not be favorable to its power to resist this erosive action of the gases. It would seem, therefore, that the most pressing necessity to the increase of the power of our guns is the discovery of a metal for the inner barrel that will resist erosion better than that now employed, rather than in an increase of the strength of the gun. Ordnance offi-

cials have some faint hope that nickel steel may prove to possess such qualities, and propose to determine the question experimentally, but their hope can hardly be said to have a basis of expectation.

Steel for the smaller calibers of cannon, including rapid-fire and machine guns, is manufactured and treated in about the same way as for the larger guns, and is obtained under about the same specifications.

For the rifle barrel, caliber 0.45 inch, a low, homogeneous, sound steel has been required, that would not harden when cooled from a heated state, and having a tensile strength of about 68,000 pounds per square inch. A much harder steel is now used for the new barrels, caliber 0.30 inch, intended for smokeless powder, having a tensile strength of at least 100,000 pounds per square inch; but the question of what steel is best for this purpose is not yet out of the experimental stage. The principal desiderata of steel in rifle barrels, after sufficient strength, are that they shall tool readily and not erode or corrode from firing—qualities that can only be determined by manufacture and proof. Hence the armory authorities have generally tried various steels until they ascertain the kind and make that gives the best results, and then purchased that, with rather meager specifications as to qualities.

STEEL FOR GUN CARRIAGES.

Gun carriages are mostly made of steel nowadays, though in some designs the massive parts are still made of cast iron. The larger members are still sometimes built up of rolled plates riveted together. But there is a growing tendency, as skill in the art of casting intricate forms increases, to use cast steel for all the larger parts, and even to cast the body of the carriage in one piece. The Navy carriages for guns up to their largest caliber, 13½ inches, having the common form of two side pieces or cheeks connected by transoms, are made in a single casting, and, as the Army is less bound than the Navy by considerations of weight, the method is quite as applicable for its use in barbette carriages. For disappearing carriages much will, of course, depend on the type which shall be adopted as a result of the experimental investigation into the question now being conducted.

The Army specifies two grades of cast steel and three of wrought steel for use in gun carriages. The softer grade of cast steel is to show a tensile strength of 60,000 pounds per square inch and an elongation in 2-inch specimens of 18 per cent, and the harder grade 70,000 pounds and 14 per cent. The three grades of wrought steel are to show, respectively, 60,000 pounds per square inch and 28 per cent, 70,000 pounds and 22 per cent, and 93,000 pounds and 16 per cent. The softer grade is used for the more massive parts, and blow-holes are allowed to such an extent as will not materially weaken the piece. The Navy specifies two similar grades of cast steel. These grades furnish ample opportunity to adapt the grade of the metal to the character and function of the part for which it is used.

Metal for gun carriages is required to be annealed at a good heat before testing, but it is not to be oil-hardened. The only limit on the chemical composition is that cast steel must not contain more than 0.06 per cent of phosphorus, and for the Navy as little silicon as is in the opinion of the manufacturer practicable.

The test specimens representing castings are cut from coupons, those representing forgings from the ends of the pieces. In addition to the tensile tests required, a proportion of the larger castings are submitted to a ballistic test, which consists of firing one or more shots of about 2-inch caliber through them from a rapid-firing gun; they must not be cracked in the test. A casting that successfully withstands this test is not thereby unfitted for use, but is accepted, together with the untested ones represented by it, and used in the service.

PROJECTILES.

The manufacture of steel projectiles may be considered under three divisions: That of projectiles forged solid, bored, and generally subjected to treatment, the type of which is the armor-piercing shell; that of shell cast hollow, the type of which is the common cast shell; and that of certain projectiles the body of which is composed of tubing, types of which are found in various shells and shrapnel cases, principally of rapid-fire calibers. As a key to the object sought to be attained in the manufacture, it may be stated that for armor-piercing projectiles the capacity to carry a large explosive charge is made secondary to the ability to penetrate armor, while torpedo shell are at the other end of the line, the penetrative power being entirely subservient to carrying capacity; common shell occupy an intermediate position and are designed to have both penetrative and explosive capacity. The use of the terms shot and shell is now somewhat ambiguous, the original distinction that one was solid and the other hollow having vanished with the disappearance of solid projectiles. The term shot is now generally employed for projectiles intended to act mainly by penetration or to have high penetrative power.

Armor-piercing shot.—There are some half-dozen principal makes of armor-piercing shot, in all of which the processes of manufacture are carefully preserved as trade secrets, so that little can be said of them in the way of description; and, indeed, it is doubtful whether a difference in the name always corresponds to an essential difference in the process. It is known, however, that they are generally made of chrome-steel melted in crucibles and cast in solid ingots, forged solid and bored, and treated after machine finishing, the metal being too hard after treatment for any manipulation except certain final touches by grinding.

The special qualities tending to success are great rigidity to resist deformation on impact and a high degree of toughness in order to resist fracture. Hardness is the controlling element for the head and point,

which have to cut a way through the opposing metal; but for the body a certain degree of toughness is necessary, as it is more liable to fracture, not being so well supported by the metal into which it enters, and should it break up the penetrative power is destroyed, while good penetration may be obtained with a considerable degree of upsetting. The treatment must, therefore, vary from the point to the base and be nicely adjusted in each part to the special object to be attained. Indeed, so great are the difficulties in the way of successful treatment of the hard metal of which these projectiles are perforce made that this operation constitutes the most critical part of the manufacture, and because of the percentage of failures from cracking during it, the most expensive as well, so that in it probably lie the most essential and characteristic secrets of the various processes in use.

The method of inspection of the manufacture of these projectiles practiced by the Ordnance Department of the Army is based on two principles: to secure uniformity of manufacture throughout each lot, and to assure satisfactory qualities for the lot by a ballistic test of some of the shot belonging to it. For the attainment of the first object the inspector is admitted to a knowledge of every detail of the manufacture, chemical tests are made of every heat and of any particular projectile that the inspector may desire, tensile tests are made of a proportion of the shot after forging and annealing, and the inspector witnesses all the treatment of every shot and the other operations of manufacture to such an extent as he may deem necessary.

The completed projectiles are presented in lots for acceptance and a ballistic test is made of each lot. The projectiles for this test are selected by the inspector, and success requires that two out of three shall pass unbroken and not badly deformed through a target composed of a best steel plate (not face-hardened) of a thickness equal to one and one-eighth times the diameter of the projectile and backed by 36 inches of oak timbers, and if one of the three breaks, all its pieces must pass through the target also. The velocity of impact is made amply sufficient to penetrate the target if the shot does not break up.

This ballistic test is very expensive because of the cost of the plate required for making it, and consequently the lots are made as large as prudence permits. The number in a lot varies with the caliber, being 200 for 8-inch, 150 for 10-inch, and 100 for 12-inch projectiles. An effort is being made by both services to reduce the expense of this item by using plates so thick as to resist perforation and cracking under the conditions of the test, regulating the severity of the test by the velocity of impact instead of by the thickness of the plate. It is believed that in this way a considerably greater number of shots per ton of plate can be withstood than when the plate is completely overmatched by the shot, as in the present test.

The practice of the Navy in the inspection of armor-piercing projectiles differs essentially from that of the Army. By it their inspectors are

excluded from all inspection and knowledge of the processes of manufacture, and select the shot for ballistic test with only such information as to hardness as they may obtain by trying their surfaces with a file. The sizes of their lots are, in consequence, somewhat smaller than those given above. Their ballistic test differs from that above described only in requiring one out of two shots, instead of two out of three, to pass unbroken through the target.

Severe internal strains are introduced into the projectile during the treatment for hardening, which, besides constituting a prolific source of loss during manufacture, not rarely causes them to fracture spontaneously at a considerable time after the treatment is performed. To guard against this and ascertain the existence of strains bordering on rupture the Army specifications require that the shot shall, at least three days after treatment, be immersed in ice water, then transferred to boiling water, and then again half into ice water, remaining in each a sufficient time to acquire its temperature. The Navy, in place of this test, adopts the plan of not paying for those projectiles that rupture within a month after delivery.

The Army uses for its 12-inch seacoast mortars a variety of armor-piercing projectile called a deck-piercing shell. It has a much larger cavity than the projectile for guns, and being intended to act only against the comparatively thin plate of decks, its ballistic test is much less sev ere, the target consisting of a 4-inch steel plate backed by 12 inches of oak. In other respects the specifications for their manufacture are similar to those for regular armor-piercing shot.

Common shell.—Until recently these projectiles have been made of cast iron, but recent advances in the art of steel casting have placed the casting of steel shells on a sufficiently certain and economical basis to enable this metal to displace the weaker one. Considerable attention is being paid to this subject by numerous steel-makers, and many special methods have been proposed or worked out having for their objects to insure soundness in the castings or to increase the strength of the shell.

The specifications for cast shells are comparatively simple. They generally require that the shells shall be annealed, and shall then show a tensile strength of 70,000 or 80,000 pounds per square inch and an elongation of about 15 per cent in 2-inch specimens cut from the shrinkage-heads where parted from the shell, and from a proportion of the shell bodies cut up for test. A limitation may also be placed on the amount of phosphorous in the metal. A hydraulic or pneumatic internal pressure test is generally employed to detect any defect that might cause leakage.

Shrapnel cases, etc.—Since the advent of electric welding this process has been largely and successfully applied to the making of shrapnel cases, shell for small calibers, etc., from steel tubing, by electrically welding a forged head to a length of tube constituting the body, the base being closed by a screw plug. The shells made for the Navy by

this process must be of metal containing at least 0.35 per cent carbon, be hardened in oil or some other suitable manner, and stand a ballistic test, which consists in firing a single shell against an ordinary ship-steel plate of a thickness equal to one-half the caliber of the projectile. This method has been successfully applied to projectiles of as high as 6-inches caliber, the limit in size in the present state of the art being fixed by the diameter of tubing obtainable rather than by any limitation of the welding power.

Another method that is employed for projectiles of from 4 to 6 inch calibers consists in cupping and drawing a short round bar of heated steel into a tube closed at one end. For shrapnel a forged head is screwed into the open end. For shells the open end is closed in hot in dies that give the proper form to the head. The small axial hole left in the head by this process is reamed out for the fuse plug. This method and also the preceding one will probably soon be extended to larger calibers and will enter into a rivalry with that of casting, the outcome of which it is difficult to predict.

ARMOR PLATE.

The manufacture of steel armor plate is of quite recent installation in this country, the first lot having been delivered only in 1892; but that it is conducted with remarkable success is shown by the tests which are equal, and for some plates superior, to any that have been made abroad, unless, indeed, foreign manufacturers keep their best results secret, which is unlikely. That we have obtained so early and great success in this branch of ordnance work is due to the fact that our Navy Department, animated by a very effective spirit of intelligent and progressive enterprise, took up and, with the efficient assistance of the two firms engaged in the manufacture, developed two improvements that came out about the time we began to make plate. These improvements are the use of nickel-steel and the so-called Harvey process, which, combined, have enabled the Bethlehem Iron Company to produce a plate that on its test in July, 1892, showed resisting qualities superior to any that have been published for any other plate ever tested.

Of these two improvements, the use of nickel-steel has been definitely adopted by the Navy Department for all ship armor. The Harvey process has been longer in the experimental stage and has not yet fully emerged from it, but it has reached the point where its ultimate adoption is certain, and most, if not all, of the plates to be furnished under the contracts recently entered into will undoubtedly be treated by this process.

The specifications that I take for this description are the revised ones issued with the new Navy contracts, and which represent the finally settled methods to be followed in the manufacture. These provide that the metal shall be nickel-steel made by the open-hearth proc-

ess and containing about 3.25 per cent of nickel uniformly distributed. The ingots must have an area of cross-section at least three times as great as that of the plate, and not over one-half of the ingot shall be used and at least 30 per cent must be discarded from the top. The plates may be either forged or rolled, and are then annealed and trimmed, and, when not harveyized, are then treated by hardening in oil and subsequent annealing. The bolt holes are drilled and tapped as the final process. The faces of the plates are left as they come from the forge except that scale is sometimes removed. The tolerances on dimensions are: in length and width, minus 0.2 inch; in thickness, plus or minus 0.12 inch; and in the versed-sine of curves, 0.1 inch per yard of chord, but not more than 0.25 inch in any 10 feet of arc.

The methods of inspection for quality are based on two principles—to secure uniformity in a lot of plates by uniformity in manufacture, and to test the lot by a ballistic test of one of its plates selected by the inspector to represent it. For the first of these objects longitudinal and transverse tensile specimens are taken for information from each end of each plate after forging and annealing, and a chemical analysis is made of the turnings from one of these specimens from each end; and two more tensile specimens are taken from the edges of the plate after treatment. From the information furnished by these specimens and his inspection of the treatment and other processes of manufacture the inspector decides whether satisfactory uniformity has been attained among all the plates of the lot and selects the plate for the ballistic test.

The determination of the caliber of the gun to be used for the ballistic test is based on the condition that it shall be as large as may be obtained among the regular calibers of the service without reducing below 1,250 foot-seconds the velocity of the corresponding service shot to develop a suitable energy. The general effect is that the caliber is as near as may be, but not less than two-thirds the thickness of the plate, and the velocities range from a minimum of 1,250 foot-seconds in the acceptance tests to a maximum of about 2,000 foot-seconds in the premium tests. Armor-piercing shot of the best quality are used. The plate is mounted with a backing of 36 inches of oak and the target thus composed is well braced. Two shots, fired with different velocities, constitute the test. For the calculation of these velocities two formulas are used, the Gâvre formula and the Marré formula. The former gives the velocity necessary to perforate a target of similar construction but containing a wrought-iron plate, and the latter that necessary to perforate a similar target containing a good plain steel plate, the projectile being supposed in both cases to suffer no deformation. The points of impact are not to be nearer than three and one-half diameters of the shot to any edge or to each other.

The first shot is fired with the lower velocity, that given by the Gâvre formula, and under it the plate must show no through crack

running to an edge. The velocity of the second shot is given for plates below 13 inches in thickness by the Marré formula, and for thicker plates by the Gâvre formula for a plate thicker than the plate to be tested by an amount varying from about one-third for 13 inches thickness to one-fourth for 16 inches and over. The target must not be perforated by this shot, but the plate may crack. This combination of a penetration and a cracking test is a most logical one from the point of view of efficiency in service, and is a distinct advance over the old method of three shots fired with low velocities, a relic of the use of cast-iron shot for testing, and under which the principal danger to the plate was from cracking, and which tended to develop a quality of plate suitable to resist damage to itself rather than perforation and consequent damage to what it is intended to protect, an order of precedence of qualities quite the opposite of that desirable for active service.

With the object of encouraging improvement in the manufacture and securing the best obtainable plates, a premium of $30 per ton is offered for plates that withstand a more severe premium test. The velocities for this test are calculated as for the acceptance test above described, but for plates of 10 and 15 per cent greater thickness, respectively, than the plates to be tested, and the Marré formula is used for the second shot for all thicknesses. This test is very considerably more severe than the preceding one, and no premium has yet been won under it, but the Department has hopes that the manufacturers will yet succeed in developing the resisting qualities of their plates to the point necessary to successfully meet it.

Nickel steel is also used for the plates that are to be treated by the Harvey process, but it is generally somewhat lower in carbon. This process consists in super-carbonizing the face of the plate by a method similar in principle to that employed for case-hardening, of which it is in fact a variety on a large scale. The process may be applied either after the forging is partially or after it is wholly performed. The extent of the carbonizing is such as to give about 1 per cent on the surface, the proportion decreasing until at about an inch depth the metal is hardly affected. The effect of the process is determined by a series of chemical information tests of drillings made at two points of the face of the plate. The hardening is done by ice water applied in numerous jets for efficacy, and to both faces simultaneously to prevent warping so far as possible, and is not followed by annealing; and if rectification of the warp is necessary it is done at a very low heat so as not to destroy the hardness of the face. The ballistic test for acceptance of these plates is the same as that described above for premiums for ordinary nickel steel.

Hollow forged armor, such as conning towers, communication tubes, and the like, are not tested ballistically, but by means of tensile specimens. Those drawn on a mandrel must show 90,000 pounds per square

inch tensile strength, and 20 per cent elongation in 2-inch longitudinal and 15 per cent in transverse specimens. Those enlarged on a loose mandrel must be oil-hardened and annealed, and show the same tensile strength with 18 per cent elongation.

I am sorry that I have not been in a position to contribute more precise information respecting details of manufacture that might be useful to any who might desire it for aid in the production of ordnance material; and this more particularly as there is a too prevailing impression that this branch of steel manufacture is a very mysterious thing, only to be succeeded in by a single and very rigid method, the knowledge of which is confined to a limited few. It is true, as may be seen from the requirements quoted, that good, solid, clean steel of about the right composition must be used, the forging must be well done, and the treatment must be conducted with great care and precision. Gun-forgings and armor-plate can not be turned out in the same wholesale way as rails or structural material. But with an adequate plant, intelligently directed, one should be able to quickly develop suitable methods capable of reducing rejections to a very small figure and consequently of insuring success. Even the most special and difficult kind of this manufacture, that of armor-piercing projectiles, has been successfully solved by one or more firms in this country on their own lines, as, indeed, have also all the processes used in making gun-forgings and armor-plates. Results and general methods only are fixed; details may and do vary, and successful methods are neither mysteriously difficult nor unattainable.

APPENDIX 47.

RAPID-FIRE GUNS. BY LIEUT. E. ST. J. GREBLE, SECOND U. S. ARTILLERY.

During the British naval manœuvers of 1890 a raid from Guernsey was made by nine torpedo boats upon the English fleet within the Plymouth breakwater. Five of these boats were of 64 tons, with a length of 127.6 feet and a speed of 20.5 knots. One was of 125 tons, with a length of 150 feet and speed of 20.7 knots, and three were of 95 tons, a length of 130 feet and a speed of 22.5 knots.

The fleet consisted of the battle ships *Northumberland*, *Anson*, *Rodney*, *Inflexible*, *Invincible*, *Triumph*, *Hotspur*, *Black Prince*, and *Hero;* the armored cruisers *Narcissus*, *Galatea*, and *Shannon;* the cruisers *Isis*, *Thames*, *Mersey*, *Medusa*, *Inconstant*, *Mohawk*, and *Racoon;* the special-service vessel *Hearty;* the sloop *Basalisk*, and the torpedo-gun vessels *Speedwell* and *Spider*.

From Guernsey to Plymouth, as the crow flies, is about 100 nautical miles.

The torpedo boats were, by the rules, limited to firing one torpedo each, although every boat had three tubes and could have fired three torpedoes simultaneously. Also, after firing each boat was required to remain on the spot and pick up her weapon, thus getting in the way of the boats astern of her and impairing the efficiency of their fire.

The fleet at Plymouth was expecting the attack of the torpedo boats, which was made by the first division at about 2 a. m. and by the second division at about 4 a. m.

Mr. Clowes[1] says that he is convinced that the torpedo boats were not sighted from the ships till they were within the breakwater, and that from the moment of the firing of the first gun to the moment when the last of the boats had discharged her torpedo barely 2 minutes had elapsed.

Four of the fleet at Plymouth were fairly torpedoed. Assuming that

[1] From paper on torpedo boats, by Wm. Laird Clowes, Journal of U. S. Naval Institute, No. 62, 1892.

all the torpedo boats perished in the two attacks, the damages for the night's work would be:

FLEETS' LOSSES.

	Value.	Men.
Northumberland	$4,030,000	688
Anson	3,625,000	524
Invincible	2,270,000	482
Inconstant	2,275,000	608
	12,200,000	2,302

TORPEDO FLEET.

Nine torpedo boats	$900,000	163

When the navies of the world found themselves threatened by these small, inexpensive, easily built vessels, which, if allowed to approach within 150 yards, meant destruction to the ship against which they discharged their torpedoes, there arose the necessity for a weapon which could keep these boats beyond their effective range.

The great high-powered guns were not easily nor quickly enough loaded and laid upon swiftly moving objects to insure this protection, and the revolving cannon which Hotchkiss had introduced in 1877 and 1879 were unsatisfactory. The muzzle velocity of their projectiles was less than 1,500 foot-seconds, and they could not be built over 4.7 millimeters in caliber, or at least, were not successfully developed over this caliber.

In response to an invitation from the French Government to build a gun which would stop the new torpedo boats of that time, Hotchkiss in 1880 constructed a single-barreled 47-millimeter continuous-fire gun which threw a 2½-pound shell. This gun was made of a single tube of high-grade steel with a box for the breech mechanism screwed on to its rear end. Finding in the trial that this arrangement would not stand the high pressures required, Hotchkiss promptly changed the design to the jacketed construction he has since so successfully developed.

In 1881 the English Admiralty invited English firms to submit 6-pounder guns to a competitive test, the conditions of which were as follows:[1]

The gun to be a breechloader and to have an effective range up to 4,000 yards with a muzzle velocity of 1,800 foot-seconds. It was to fire shell and steel shot 6 pounds in weight, the ammunition to be fixed. The gun to fire at least twelve rounds per minute with a crew of three men or less; the mountings to be suitable for ship or boat with an alternative for field service. The recoil was to be reduced to the lowest limits and the gun returned to its firing position after recoil; the mount to allow of an all around fire.

[1] Extracts from Lieut. W. H. H. Southerland, U. S. Navy. General Information. Series No. IX.

There were also provisions made for a removable shield proof against Martini-Henry bullets at 100 yards, while the total weight, including ships mounting, was not to exceed 10 hundred weight.

The French Government, about this same time, issued the requirements for tests of 3 pounders and invited competitions.

The guns submitted to have 1,900 feet seconds muzzle velocity, and to fire a steel armor piercing projectile which would penetrate five-eighth-inch steel plates, 30 degrees to the normal, at a distance of 2,624 yards. Twelve aimed or twenty-five unaimed shot were to be fired per minute. Hotchkiss alone responded to the French Government's invitation. He furnished a gun which gave a muzzle velocity of over 2,000 feet seconds, and whose shell penetrated at 4,300 yards the five-eighth inch steel plate placed 30 degrees to the normal. This gun was adopted by many nations as part of their ships armament. Hotchkiss, Nordenfelt, and Armstrong presented 6-pounders to the English Government. Armstrong withdrew his gun and Hotchkiss and Nordenfelt were finally given orders to furnish their guns for the English ships.

To meet the navy requirements for a gun having great accuracy and penetration, ability to train quickly and keep easily on swiftly-moving objects, and to throw a great number of projectiles in a short time, the rapid-fire gun was constructed.

It may be defined as a single-barreled breech-loading rifle using metallic-cased ammunition, the projectile being usually joined to the case. The extraction of the empty case and the cocking of the striker is performed by the opening of the breechblock. The ejection of the case may also be effected by this same movement. The loading is performed wholly or in part by hand, and where recoil is permitted the gun is automatically returned to its firing position. Abroad these guns are called quick-firing.

Machine guns, properly including revolving cannon, are distinguished from the rapid-fire guns in that they are loaded automatically and that the loading and firing proceed automatically and continuously by the operation of mechanism contained in the gun. This mechanism may be operated by man power or by the force of the recoil of the piece.

Rapid-firing guns are usually designated by the name of their makers and the weight of their projectile, or by the diameter of their bore in inches, millimeters or centimeters, and their length in calibers. Thus we say the Hotchkiss 6-pounder, or 2.24-inch or 57-millimeter 30-caliber rapid-firing gun; the Canét 12-centimeter 80-caliber quick-firing gun.

Until 1885 Hotchkiss and Nordenfelt practically monopolized the construction of rapid-firing guns. To-day there are at least eighteen firms making these guns.

Originally intended as a protection against torpedo boats, they have grown in size and power, as increased protection was given to these boats, until they have outgrown their original rôle of auxiliary war material.

The little 2½-pounder has developed into a 6-inch high-powered gun with a range of over 16,000 yards and a penetration of wrought iron of nearly 15 inches. Canét makes over twenty-one types of these guns, varying from 65 millimeters to 15 centimeters. Hotchkiss has designs for twenty-one types, varying from the 37-millimeter, 1-pounder, to the 155-millimeter, 100-pounder. Grusonwerk turns out sixteen types. Armstrong, Schneider, Krupp, Dashiell, Driggs-Schroeder, Seabury, Gerdom, Nordenfelt, Maxim, Engstrom, Skoda, Thronson, Daudetau-Darmancier, Maxim-Nordenfelt, Nordenfelt-Cockerill are all names familiar to those interested in rapid-fire guns.

The navies of all nations are crowding their ships with these guns, so that the quick fire of a vessel is for most purposes often more formidable than that of her heavy guns.

With smokeless powders some of these guns will give over 3,000 feet seconds velocity to their projectiles. Canét built a 10-centimeter 80-caliber gun which gave a muzzle velocity of 3.366 foot-seconds to a 28.7, pound shot, while a 6-inch 100-caliber Armstrong gave, in January, 1893, a muzzle velocity of 3,231 foot seconds to a 100-pound projectile and 3,711 feet seconds to a 70-pound projectile. These guns were merely experimental, but the results lead to speculation as to what may be possible in the future of quick-firing guns.

Rapidity of fire results from the quickness with which the different operations of loading and laying can be performed. Between two rounds from the ordinary breech-loading gun, the following operations are necessary. The breechblock is unlocked and moved out of the way so that the charge can be inserted, the gun is returned to battery, the charge inserted, the breechblock closed, a primer put in place, the gun laid, and if the whole mount has appreciable recoil the detachment must be gotten out of the way while the gun is fired. If time fuses are used, these must also be set.

The maximum of rapidity will be obtained in that system which performs each of these operations in a time so short as not to interfere with any of the others. Improvements in steel and knowledge of gun construction give to the guns of most nations the ballistic properties desired.

The use of metallic-cased ammunition, *i. e.*, ammunition in which the powder charge is contained in a metal case, which also carries a primer of some sort, helped greatly in obtaiñing the required rapidity. Fixed ammunition reduces the time necessary for inserting the charge to a minimum, does away with a separate insertion of a primer, and the metal case, acting as a gas check, reduces the weight of the breech-block and simplifies its construction. The case also, by preserving the powder, increases the accuracy of the piece.

The operation taking the greatest time in the old guns and entailing the greatest fatigue on the detachment was the return of the gun to battery. The smaller quick-fire guns are mounted on nonrecoil mounts and the larger ones on recoil mounts which automatically return them

to battery. In recoil mounts the gun is carried in a cradle, within which the gun recoils. The cradle is swung on trunnions, and contains the recoil check cylinders and the springs or other arrangements for returning the gun to battery.

The direction of recoil is parallel to the axis of the piece when fired. A shoulder piece is usually bolted to the left cheek of the slide. The sights are also carried by this cheek. In the non-recoil mounts the shoulder piece and the sights are attached to the gun. In the larger recoil mounts the laying is performed by hand gear or by small electric motors carried on the mount.

In the smaller recoil mounts and in all the non-recoil mounts the layer, by applying his force to the shoulder piece, lays his gun and may clamp it in traverse and elevation. The gun is fired by electricity or by lanyard, and sometimes automatically by the closing of the block.

The improvements in these mounts permit the layer to remain in his position and to keep the gun trained on any object. They form the most important part of any rapid-firing system, and in the parts with which we are most interested, for it is aimed rapid fire that we seek. Smokeless powders and these recoil mounts give us this sort of fire with almost any system of breech mechanism and guns, provided we use fixed ammunition not too large to be quickly thrown into place by two men.

Strange to say, the comparatively unimportant breech mechanism is the part which has occupied the attention of most designers.

Breech mechanism may be divided into two general classes—the wedge, as seen in the Hotchkiss, Nordenfelt, Gruson, Krupp, and Driggs-Schroeder, and the interrupted screw used by Canét, Schneider, Seabury, Dasheill, and Gordon.

The wedge for large guns is heavy to operate, especially when working vertically. It has, moreover, unless modified, a tendency to guillotine the head of the cartridge case, should this case be not thoroughly seated.

The extracting devices should take their grip on diametral ends of the cartridge head and remain always in front of the head, so many think. It would seem that any device which is simple, strong, and sure is good enough.

The extractor, after it has loosened the case, may be given a rapid motion by the swing or fall of the breechblock and thus eject the empty case.

In some of the interrupted screw blocks the operations of rotation, withdrawing, and swinging the block clear of the bore are performed by a continuous motion of a lever or handle. These are pretty to look at in motion, but there is no practical saving of time in loading by these devices and they are more complex than some other systems. Simplicity, strength, certainty of action, easy of construction and of repair, cheapness, and lightness must all be considered in comparing different systems.

A short description of a 3-pounder gun may be of interest to those who are not familiar with rapid-fire guns. The Hotchkiss system is taken, first, because to Mr. Hotchkiss we are indebted for the development of this arm; and, second, because his excellent book on the Hotchkiss system of rapid-fire guns permits me to give much concise information. The following is an abstract from this book.

The steel used in the body of the Hotchkiss rapid-fire guns is tempered and annealed after tempering.

It must possess the following qualities. Test pieces, 2.7 inches between measuring point used. Limit of elasticity, 51,500 pounds per square inch; tensile strength, 94,000 pounds per square inch; elongation after rupture, 15 per cent.

The accompanying plate shows the construction of the system.

The rifling of the Hotchkiss system is right-handed; that for the 37 and 47 millimeters being constant, and for the others increasing.

The travel of the projectile is from 32 to 34 calibers.

The breechblock is of the wedge system; it works vertically, and in opening is allowed to fall freely. The block is rectangular in its horizontal section, with rounded corners. The front face is exactly normal to the axis of the piece, while the rear face is slightly inclined or wedge shaped. The breechblock carries the firing mechanism.

As the block moves vertically and falls of its own weight, the function of the mechanism for opening and closing is to lift the block straight up in closing, and to keep it either from falling open when closed or from falling out of the gun when opened.

It is lifted by means of a crank having a stud on the end. This stud fits in a slot way in the right side of the block, and the block rests entirely on it; when, therefore, the crank is turned the stud sweeps down or up through its arc and the block is carried down or up with it. To keep the block from falling out of the gun, a stop bolt is screwed through the left side of the breech, entering a slot in the left side of the breechblock. The length of this slot determines the run of the block.

The crank is moved by handles on the outside of the breech at the right side. When the breech is closed the block is kept from falling by the crank being slightly past the vertical to the front and also by a light automatic spring catch on the handle.

The hammer is pivoted on an axle called the rocking shaft, which is hung to the lower front part of the breechblock.

The hammer is cocked by the movement of the lever which opens the block. On the end of the rocking shaft, projecting from the right side of the breech, is a short lever or cocking arm, and on the crank handle is another short lever or cocking toe. When the crank is turned in opening the breech the toe presses on the arm and thus revolves the rocking shaft throwing the hammer back.

To hold the hammer at full cock, there is a notch on the rocking shaft into which drops a stud on the sear, which is simply a lever against whose under side a spring presses to hold it up constantly.

To fire the gun, the free end of the sear projects slightly beyond the rear of the breechblock. By pressing down on it the cock notch is freed, and the hammer impelled by a powerful main spring flies forward.

The empty cartridge cases are extracted by a small bar of steel with a stout claw at its end which engages in a slot way in the breechblock, so that the down and up movement of the block gives an out and in movement to the extractor.

The breech is opened and the hammer is cocked by pulling the crank handle to the rear. As the handle commences to move the crank stud is carried backward in the port of its groove which is concentric with the axis of the crank; the breechblock, therefore, does not move. During this time the cocking toe acts on the cocking arm and cocks the hammer. The crank stud passing on into the straight part of its groove, the breechblock commences to descend. The extractor, actuated by the movement of the block, commences to move very slowly back with a powerful leverage, starting the cartridge case from its seat. When the block has descended so far as to unmask the bore, the change in the direction of the extractor stud groove causes the extractor to take a quick violent motion to the rear, throwing the case out of the gun. The block is at this point stopped in its descent by the stop bolt.

The gun is ready for loading.

The charge is entered in the chamber and pushed home until the head of the case takes against the hook of the extractor. The block is closed by a reverse motion of the crank handle. As the block rises, its inclined upper corner pushes the cartridge and extractor close home.

When the breech is closed the cocking toe is in position to allow the cocking arm, and with it the hammer, to act in firing. Pulling the trigger now fires the charge. The accompanying plates show the ballistic properties of this gun and need no explanation.

Firing table—Hotchkiss 3-pounder rapid-firing gun.

Common shell:	Feet.	Service charge:	Pounds.
Initial velocity	2,002	Charge	1.71
Angle of jump	0	Projectile	3.3

Length of line of sight, 37.48 inches.

Angle of inclination of sight bar, 1 degree.

Range.	Angle of fire.	Angle of fall.	Sight marks.	Actual drift.	Time of flight.	Remaining velocity.	Mean deviation.		
							Range.	Direction.	Height.
Yards.	*Deg. Min.*	*Deg. Min*	*Inches.*	*Yards.*	*Seco'ds.*	*Feet.*	*Yards.*	*Yards.*	*Yards.*
100	0 10	0 10	.11	Right 0.05	.2	1,926	16.2	.02	0.05
1,000	0 59	1 13	.64	Right 0.44	1.9	1,361	12.4	.32	0.27
2,000	2 28	3 35	1.60	Right 0.5	4.5	991	10.7	1.06	0.68
3,000	4 39	7 26	3.05	Left 0.5	7.9	843	10.7	2.51	1.49
4,000	7 40	13 5	5.03	Left 3.1	11.2	738	13.2	4.92	3.37

In the supplement to this article will be found details of some other systems and notice where description of all systems can be found.

Since their original conception the Navy has never had any doubts about the value of the rapid-fire guns.

They have on shipboard supplanted all other guns of like caliber, until now it is safe to say that all naval guns in the future below 6 inches in caliber will be rapid-fire.

Admiral Albini advocates mounting 46 of these guns in a battleship and 50 and 30 in first and second class cruisers, respectively.

England, during the year ending December 31, 1892, added to her naval service eight 6-inch and two hundred and twenty-five 4.72-inch Armstrong quick-fire guns, making in all 1,715 of these guns afloat and in reserve in her navy at that date. Since then ten 6-inch rapid-fire guns have been mounted on the *Royal Sovereign*.[1]

France's naval budget for 1892 appropriated $148,000 for converting her 10, 14, and 16 centimeter breechloading rifles to rapid-fire guns; $848,000 for the construction of new rapid-fire guns; $730,000 for fixed ammunition for the former and $440,000 for the latter, and allowed a contingent of $200,000 to be used at the discretion of her minister of marine.

Spain is converting her smaller naval guns to quick-fire, and the South American States are buying cruisers armed principally with these guns. France seems to prefer the Canét system; Austria, Germany, and Holland, the Krupp; Russia is undecided between the Canét and Nordenfelt, with probably a leaning towards Canét; England has the Armstrong, and the United States Hotchkiss, Driggs-Schroeder, and Dashiell.

A modern ship armed with ten 6-inch, sixteen 6-pounders, eight 3-pounders, and 8 machine guns, will in four minutes fire 22,552 projectiles from this armament, as follows:

Gun.	Rounds per gun per minute.	Total rounds.	Total weight of projectiles.
Ten 6-inch	7	280	28,000
Sixteen 6-pounders	12	768	4,608
Eight 3-pounders	12	384	1,152
Eight machine	660	21,120	1,050
Total	.....	22,552	34,810

If she can bring only one-half these guns to bear she still fires 11,276 projectiles, weighing 7 tons 15 cwt. 45 pounds. Of these the 140 from the 6-inch possess a muzzle penetration of 14 inches of iron, the 384 from the 6-pounders a muzzle penetration of 5 inches, and the 192 from the 3-pounders a muzzle penetrative force of 4 inches of iron.

[1] General information, series 1892.

Such a hail of projectiles would prevent the working of any unprotected guns coming within their reach.

Rapid-fire guns have indeed changed the designs in armor protection aboard ship and made the extension of armor a necessity.

With a mention of the performance of a 6-inch gun on an Elswick mount aboard ship I will leave the Navy and ask you to turn your attention to Army needs for these same guns.

This 6-inch gun, using cordite, gave a muzzle velocity of 2,660 foot-seconds to a 100-pound projectile with a point-blank range of 1,000 yards. Three series of ten rounds each were fired in 1 minute 57.8 seconds, 1 minute 59.8 seconds, and 1 minute 58.3 seconds.

In the land service the rapid-fire gun is naturally considered in connection with seacoast, siege, and field artillery.

Maj. A. C. Hansard, R. A., defines a coast fortress as an area of land and sea, provided at certain points with an artillery armament partly fixed and partly movable, and its area is the extent of land and water which can be covered by the fire of its guns.

To keep ships from running past these guns the channels and often all water deep enough to float large ships are planted with mines and other obstructions, which we artillerymen think properly belong to the fort's defense.

A place is defended by a coast fortress when the fire from its guns can delay any presumable hostile fleet from passing it for a time sufficient to allow the home fleet to come to its assistance.

The modern war ship is not designed to attack shore fortifications.

Two of her dangerous weapons of offense, the ram and torpedo, can not be used against land guns, and her fire is from a movable platform against dispersed, well-concealed, and quite small targets.

A large vessel is too valuable to engage in combats with the odds all against her, so that she will not, as a rule, run the risk of being sunk or disabled far from home. It seems to be the opinion of at least some naval authorities that a strongly-fortified harbor will not be directly attacked by ships. Certainly it will not be unless its capture is exceedingly important and as a last resort. If ships do attempt the attack of a fort, they will come in sufficient numbers to have at least three or four times as many large guns as they expect to find mounted on shore, and they will try to silence those shore guns quickly. To do this at all they will come to close range and anchor, for it is only by the superiority of accurate fire that they can hope to silence the land gun; besides, at long range, the land guns would have all the advantage. So it seems safe to say that they will get in close if they really mean to reduce the fortress.

The rapidity with which large guns mounted on board ships and controlled by hydraulic machinery can be fired is often the subject of question. The table given below shows the rapidity of firing these

guns when worked entirely by hand and when worked by hydraulic machinery:

Ship.	Description of gun.	How worked.	Results.
Colossus.....	12-inch 45-ton B. L.....	Hydraulic	4 rounds in 3 minutes; target struck 3 times.
Trafalgar.....	13.5-inch 67-ton B. L.....	....do	4 rounds in 9 minutes 7 seconds.
Benbow	16¼-inch 110-ton B. L.....	....do	3 rounds within 6 minutes. Started with gun loaded.
Thunderer.....	10-inch 30-ton B. L.....	Hand	1 round in 2 minutes 10 seconds.
Imperieuse	9.2-inch 22-ton B. L	....do	3 rounds in 6 minutes.

Ships are then able to fire quite a lot of large projectiles at the shore guns, but this will be nothing compared to the rain of metal thrown from the machine and rapid-fire guns which it has been shown these ships will carry. This latter fire is most to be feared, and must be kept under, or the exposed guns of the fort can not be worked. This fire can only be kept down by a return fire of the same sort from the shore guns. To permit the primary unturreted gun to be used, unless these guns are on elevations, the fortress must mount rapid-fire guns in large numbers.

The heavier war ships have their vitals well protected. Their primary armaments are behind armor, but four-fifths of their guns and much the greater part of the ship and machinery is not protected except against small arm projectiles.

At 3,000 yards the 12-centimeter 50-caliber Canét will penetrate 5 inches of wrought iron, and the 15-centimeter 50-caliber will penetrate nearly 7 inches. From the 3-pounder up, all will throw projectiles which will render the unarmored parts of the ship untenable, and which may, by a lucky hit on the turrets or guns, disable even ships of the *Dreadnaught* or *Miantonomoh* type.

Indeed, it would seem that by properly looking to the enplacement on shore of the 12 and 15 centimeter rapid-fire guns that an effective bombardment would be impossible by any except the heaviest armored ships, for all others would, by the fire of these guns, be driven to long range. Against cruisers the 12 and 15 centimeters are effective, so that in minor harbors these would probably afford all the gun protection necessary.

After silencing the heavy gun on shore the attacking fleet will, under the cover of darkness, send out her creepers and countermining boats to clear a passage through the mines.

To keep these boats from doing their work no arm can compete with the rapid-fire guns. It was for this very work, the attack of small craft, that the navy developed this gun, and if it has been found efficient in sea for this purpose it will prove more so on land.

As long as these small boats are kept away from the mine fields the large ships can not, without much risk, enter, so again the rapid-fire gun protects the harbor. The position of these rapid-fire guns in sea-

coast defense will probably be away from the large guns, so that the shell fired at the latter will not affect the former. They will be in groups of three or four, electrically connected with the fort commander.

Being dispersed and on the flanks of the large guns, they will offer flank defense to these. If there are heights along the coast a plunging fire can be obtained on the vessels by mounting the rapid-fire guns on these heights.

If necessity compels the guns to be mounted near the water-level, balance pillar mounts and shields will be employed.

The accompanying photograph shows the 4.72-inch Armstrong rapid-fire gun on its balance pillar mount.

The object of this mount is to enable the gun to be kept out of view of the enemy when lowered behind the parapet and to enable it to be quickly raised when required for use.

The balance pillar consists of an outer cylinder, an inner cylinder, and adjustable counterweights with spring attachments, three steel pillars with brackets and sheaves and tiebar, three wrought-iron chains with equilibrium lever and suspending bolt, and the raising and lowering gear.

A traveling loading-stage is supplied, which runs on steel rails placed in a circular path round the mounting. The outer cylinder is sunk in a concrete foundation. Inside of this works the inner steel cylinder, on the top of which is placed the gun mounting. The weight of this inner cylinder and its load is balanced by means of the counterweights, which work up and down inside the inner cylinder.

The sheave pillars pass through holes in the counterweights and rest in sockets at the bottom of the outer cylinder.

The chains pass round the sheaves. To one end of each chain is attached the lever, from which are suspended the counterweights; to the other end of each chain is attached the inner cylinder; the inner cylinder can be raised 42 inches above the outer cylinder; the time for two men to raise or drop it being about fifteen seconds.

The raising and lowering is done by a gear consisting of a toothed rack riveted to the inner cylinder, into which is geared a toothed pinion on a cross shaft. On the end of the shaft is shipped a ratchet lever by which the gear is actuated.

The mount is supplied with two batteries for firing by electricity.

This is a beautiful mount for the guns, and a fortress supplied with them in sufficient numbers would be a hard adversary to subdue.

We will then have in coast defense the 3 and 6 pounders to defend the mine fields and fire at the unprotected ports of the attacking fleet. The larger calibers will also be mounted in large numbers to do the same work, only more of it, the position of the guns to be dispersed and well concealed and not mixed with the heavier armament.

In the April number of the Royal Artillery Institute Journal, 1892, Lieut. Buckle, R. A., gives a detailed scheme for the employment of rapid fire guns in harbor defense.

In siege operations only the same story can be told. Intensity of well-aimed fire employed by the besiegers will keep the besieged from repairing breaches, drive him away from his parapets, and make his defense passive, or, if used by the besieged, it will delay or render impossible the ordinary operations of the besiegers.

It is here as ever, superiority of fire which tells, whether we obtain it by numbers or weapons.

The magazine small arm, the machine gun, the rapid-fire gun all have been developed to comply with this military maxim. Why dilate upon it? Where other guns are good rapid-fire guns of the same caliber and power are better, for they will throw more projectiles in the same time than will the other guns.

In coast defense and siege warfare weight in guns and mounts is not of much importance. As long as a gun can be dragged over poor roads it is light enough for siege operations, and the opponents of rapid-fire guns can not well offer in these two services the weight of the mountings as good objections against this system.

Gruson has developed a shielded mounting which lends itself well to the needs of siege warfare. It consists of a gun in a sheet steel cylindrical structure with an armored dome roof. It has room within for the ammunition and one or two gunners, and is closed at the rear by strong doors. The mounting is on wheels so that it can be dragged around by horses, or if mounted in a fortress it runs on a track and can be easily pushed around to any desired position by men.

The mounting of the 2.24-inch 25 caliber weighs about 2.85 tons, has a detachment of eight men, and is moved over tolerably rough ground by three horses. This gun was fired at 1,640 yards against targets representing twenty skirmishers and supports in rear of each flank of ten men each; one hundred and seventy-two hits were made on the skirmish target and fourteen on the supports. Nine men practically intrenched this mounting in sand in twenty and one-half minutes.

Pushed out by the besiegers or besieged in position well flanked by their fire, these mountings would be valuable, but it is doubtful if they could be relied upon to protect themselves from infantry attack.[1]

In approaching the question of the employment of rapid-fire guns for artillery service in the field, one is met with two very serious difficulties; the most serious is that no really satisfactory rapid-fire gun has ever seen field service, and the other difficulties are that foot artillerymen and horse artillerymen and other artillerymen have written much

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[1] During the event of possible future siege operations from the establishment of the first artillery position to that of the third parallel and rush of the assaulting columns over the débris of the broken down escarp, the perfection of modern siege equipment will place the besieged at a disadvantage unless provided with an armament of rapid-fire guns. With these, however, the fire of the defenders can be so skillfully and rapidly concentrated on parallel or assaulting columns that Capt. Stone, R. A., is of the opinion that the prosecution of ordinary siege operations will be rendered impracticable.

that appeals to one, both pro and con—the employment of rapid-fire guns for field service.

I refer those who would like to read some of these discussions to the following articles: The Field Gun of the Future; Maj. E. Lambert, R. A., Journal of the Royal Artillery Institute, October, 1892; Canons a tir Rapide et L'artillerie de Campagne, Revue de l'Artillerie Belge, April, 1891; Field Guns versus Howitzers; the United Service Magazine, September, 1892; Quick Firing Guns in the Field, by Capt. Headlam, R. A., in Engineering, March 31, 1893; Col. Langlor's French Army, Mr. Nordenfelt's articles on rapid-fire guns in the field, and Gen. Wille's field gun of the future and the numerous criticisms it has evoked.

The principal objections urged against the adoption of rapid-fire guns for field service are that rapidity of fire is obtained at the expense of weight of the projectile; that nonrecoil mounts are heavy and traversing gear unsatisfactory, and that metallic cased ammunition is so jammed and injured by the rough treatment it receives in field transportation that it will not function in the gun, and that the use of metallic cased ammunition increases dead weight to be carried.

If a rapid-fire mount can be devised for field service which will not be too heavy and will protect its crew from small-arms fire, this is the mount we should have. The difficulties to be overcome are not so great but that with governmental encouragement nearly any one of the great firms who make these guns would, I feel sure, shortly overcome them.

Much will be expected of artillery in the field in future campaigns. Wonders have been accomplished by it in the past.

The artilleryman will be called upon to die by his guns that battles may be won. By being on hand when wanted, by a fearless policy, by doing well the work asked of it, the artillery has gained its high position. It can only keep this position by doing in the future what it has done in the past.

The introduction of rifled small arms marked the change in field artillery methods of fighting. The first position has steadily increased in distance from the hostile guns till to-day ranges of over 5,000 yards are demanded of these guns, and the artillery duel at long ranges with much waste of ammunition resulted.

Complicated regulations, heated discussions as to the proper way of opening and directing fire, range finders, telescopic sights, high velocities, with a necssary increase in the weight of guns, mounts, and charges resulted.

After a time from the first position the guns are gradually moved nearer as they establish a superiority of fire and finally go up on the infantry line after a successful assault by this arm.

Artillery can defend itself from the other arms so long as it has ammunition and a detachment to serve it, and it is generally conceded that in artillery fights that gun which first gains the range will be successful.

Senarmont at Friedland saved the battle to Napoleon by the intensity of artillery fire he poured upon the Russian at short range. The Germans in 1870–'71 fought their guns successfully at almost point blank small arm range.

In the war between Servia and Bulgaria in 1885, at the battle of Slievnitza, an incident occurred which enables us to form some idea of the importance of superiority of fire.

At one period of the action two Servia batteries (8 guns) opened fire on the left center of their opponents at a range of about 1,500 meters, and Prince Alexander detached two guns under Capt. Matthieff to engage them.

Selecting a position for his two guns, he ascertained the range with a near approach to accuracy. The absence of reliable noncommissioned officers compelled him to adjust every fusee himself.

His first shell was short, his second fell among a team in rear and did great execution, while his third burst about the correct distance short of the Servian batteries. With this length of fusee, therefore, he continued to fire, still adjusting each with his own hand for six minutes, at the end of which brief period the Servian guns had enough, and limbering up with great difficulty and severe losses, both of men and horses, were taken out of action. Here two guns put eight out of action in six minutes. What results would such a gun captain have obtained with quick-fire guns, firing at least eight times as rapidly as the ones he used?

Every man who has hunted much over varying ground knows the difficulty of judging distances. Few men will estimate distances accurately over 500 yards.

In firing on the practice ground it is the same thing; ranges at a mile have to be picked up with as much care as ranges at 3 miles.

It can be done more quickly at the shorter ranges because the eye can easily and more accurately tell where the shots strike. Still we have to pick them up at all ranges greater than the point blank.

A review of the few points touched upon concerning field artillery show that it was small-arms fire which drove field guns to long opening ranges. The rule is to open the fight at the shortest range consistent with "not too much loss." Still there comes a time when disregarding small-arms fire and irrespective of loss, artillery must come up on the infantry line and stay there. It has been demonstrated that field artillery can, as long as its detachment is capable of serving the pieces, protect itself from the other arms, and we are taught to believe that the gun which first gains the range will be successful.

Why not then strive to perfect an arm which will permit the opening range to be at short distances. Protect the gun detachment by steel shields from small-arms fire. This will allow the gun to come into action at short range without too much loss. If the ranges do not exceed 1,000 to 1,500 yards high velocities will not be needed for accurate

shrapnel fire, and it would seem that with these low velocities a mount could be devised which would fill the requirement of rapid-fire system. If our guns can then fire six to ten shots in the time the other guns are firing one, they will be able to range quickly and consequently gain the ascendency over their slow-firing long range high-powered opponents.

Such comparisons as these lead us to the inevitable conclusion that rapid-fire guns are no longer in their elemental stages. They are an established success in the navy, and have responded to all the demands which have been made upon them.

That they may render this maximum of efficiency requires trained crews, and layers with a practical knowledge of the weapons they handle. That they will in the near future fill the same place on land that they now fill on sea is inevitable, and in view of this, their development, their emplacement, and the furtherance of such knowledge as will lead to their most effectual use, should be an object of interest to all military men.

RAPID-FIRE GUNS.

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GERDOM RAPID-FIRING BREECH MECHANISM.

The Gerdom rapid-firing breech mechanism is a modification of the interrupted screw system.

It consists of twenty-six parts, including seven screws, three springs, and two hinge pins. (See Pl. A.)

The breechblock (see Pl. A under Fig. 2) is for two-thirds of its length from the front end back composed of two threaded cylindrical surfaces and two parallel plane surfaces.

It is formed from a cylindrical plug threaded from its front end for two-thirds of its length. A portion of the threaded part of the block is then cut away by two planes passed parallel to each other and to the axis of the block; each plane being at a distance from the axis equal to the radius of the base of the chamber, leaving for the periphery of the block as far as the threads extend two threaded sections opposite each other and each covering 90 degrees, and two plane surfaces joining the threaded surfaces.

When these plane surfaces are in certain positions they are parallel to the upper and lower surfaces of the slot cut in the side of the breech and the block can be withdrawn from the gun by passing through this slot.

When the block is revolved so that the planes are 90 degrees from this position the threads are fully engaged in their seats cut in the breech of the gun and the block is locked.

The rear end of the block is cylindrical. It seats in the carrier ring (Fig. 21, Pl. A). It has in this ring a motion of rotation of 90 degrees, and a motion of translation of one-fourth the pitch of the screw.

A slot cut in the outside cylindrical part of the block takes the end of the stop screw shown in the picture of the carrier ring (Pl. A) and limits the motions of the block in his ring. The block is bored to receive the firing pin (Fig. 13) and its spring (Fig. 12). The front end of the firing spring rests on the lug near the striking end of the pin. The pin and its spring are inserted from the front end of the block, and this end of the block is then closed by the threaded cap. Shown in Pl. A, under Fig. 12.

The center hole in this cap permits the striking end of the pin to come through to the front in certain positions of the block and to hit the primer.

The rear end of the block is counterbored and slotted to receive the operating lever (Fig. 1), the locking latch and its spring (Figs. 2 and 3), the cocking lever (Fig. 14), its hinge pin (Fig. 15), the trunnioned collar (Fig. 16), the notched cap (Fig. 11), and the sear and its spring (Nos. 17 and 18). Plate B shows these latter parts in position in the block. The toe of the cocking lever projects past the rear circumference of the block and engages in a spiral groove cut partly in the rear face of the carrier ring and partly in the cap (Fig. 19) which screws over this part of the ring.

The rotation of the block in the ring travels the toe of the lever through this groove and gives the whole lever a motion about its hinge (Fig. 15).

The other end of the cocking lever terminates in a fork which carries the trunnions of the collar, Fig. 16. The collar being slipped over the firing pin, and having its motion to the rear with reference to the pin limited by the screw cap (Fig. 11), the motion of the cocking lever about its hinge withdraws the firing pin to the rear; the firing spring is compressed and the pin is held in its firing position by the sear (Fig. 17), which catches in the notches on the screw cap.

The sear seats in the groove (shown in Pl. A) cut nearly across the rear face of the block. It is pressed against the screw-cap notches by its spring (Fig. 18). A projection on the sear stands out to the rear through the rectangular cut in the face plate (Fig. 7).

It is here rigged for firing with a lanyard, although it could be easily modified for firing by trigger or by electricity.

Pulling the sear to the left disengages it from the notch on the screw cap, and the firing pin is by its spring driven to the front. As long as the toe of the cocking lever is at any position of the spiral groove except that it occupies when the block is closed, the pin is prevented from driving far enough forward to strike the primer.

The screw cap on the firing pin projects to the rear through the central hole in the face plate. It terminates in a ring, used for cocking the pin by hand.

The operating lever seats in a circular slot cut in the rear face of the block. A tooth on the lever engages in a slot in the locking latch. The lever has a slight motion with reference to the block in a plane perpendicular to the block's axis. This slight motion gives the tooth sufficient throw to unlock the latch. The lever then butts against a shoulder on the block and its further motion rotates the block to unlock.

The extracting devices are shown in detail in Pl. A, Figs. 8, 9, 10, and in position by Pl. B.

No. 8 engages in front of the cartridge head and grips it for more than one-eighth of its circumference. Its motion is guided parallel to the axis of the piece by two cylindrical arms working in slots cut in the breech.

The under part of this piece from the arms towards the curve is slightly beveled to seat the bevel on No. 10 piece.

If No. 10 in plate A were pushed towards No. 8 the beveled surfaces would about come into position.

No. 9 is a stop screw seating in the breech and limiting the motion to the rear of the piece No. 8.

The inner front part of the carrier ring is cut away about its hinge to permit No. 10 piece to enter it and be held in position by the carrier-ring hinge pin.

The inner surface of the ring is formed into a cam, whose elements are parallel to the axis of the hinge pin.

A hole is so drilled through piece 10 that the hinge pin will hold it in place and still allow it sufficient play for the shoulders to play over the cam.

Swinging the carrier ring around its pivot drives the shoulders of No. 10 piece hard against the cam and forces No. 10 towards the axis of the piece, under the bevel on No. 8, and acting as a wedge under No. 8 it drives this piece to the rear slowly and loosens the cartridge case.

After passing over the cam No. 10 seats on the inside of the cut made in the carrier-ring and then moves with it; acting from this point as a lever under No. 8 it gives this piece a rapid motion to the rear and the case is thrown out of the gun or far enough to the rear in the breech to be easily removed by hand.

The carrier ring is seated in a slot cut through the breech from the base of the chamber all the way back.

The width of this slot is just a little greater than the distance between the parallel plane faces of the block, so that when these faces are in proper position the block can easily pass through the slot. The ring is hinged by a vertical pin (see Plates A and B), and swings horizontally in opening and closing the breech.

The operation of the mechanism of the gun being fired is as follows:

The operating lever is seized with the left hand and a handle on the right rear face of the carrier ring with the right hand.

The lever is pulled slightly over 90° to the left.

The first motion of the lever unlocks the cocking latch, the remainder of the motion rotates the block in the carrier ring, disengaging the screw threads.

During this motion of rotation the cocking lever has pulled back the firing pin, which is held in position by an edge of the sear engaging under a notch on the screw cap. The carrier ring is then swung to the left by the handle in the right hand.

The block moves to the left with the ring and passes partly through the slot out of the breech and uncovers the bore.

The first motion of the ring loosens the cartridge case, as before described, and then ejects it. The new charge is thrown in, no care being taken to seat it; the ring swung to and the block rotated and locked. As soon as the block is locked pulling the sear fires the gun.

The Gruson system of quick-fire guns.

[Compiled from the Gruson quick-fire guns, by Julius von Schütz, engineer of the Grusonwerk, first and second parts.]

Kind of gun.	Principal use of gun.	Material of which tube is made.	Assembling of gun.
3.7cm, 1.46 inches, 23 calibers	Specially constructed for Grunson movable shielded carriage.	Forged crucible steel.	Made in two parts, the cylindrical barrel and the breech piece. The breech piece is screwed to barrel and forms a jacket 7.87 inches long.
3.7cm, 1.46 inches, 30 calibers	For mountain gun and boat's gun.	....do	Do.
4.7cm, 1.85 inches, 30 calibers	For field and casemate mountings,	....do	Barrel is screwed into 8-sided breech piece, which acts as jacket for 15.79 inches.
4.7cm, 1.85 inches, 40 calibers	For naval mounts against torpedo-boat attack.	.....	Breech piece acts as jacket for 21.7 inches.
5.3cm, 2.09 inches, 24 calibers	For movable and disappearing shielded mounting and ditch defense.	.....	Breech piece forms jacket for 12.8 inches.
5.3cm, 2.09 inches, 30 calibers	For field mounting.....	.....	Breech piece forms jacket for 15.8 inches.
5.3cm, 2.09 inches, 39 calibers	For naval service against torpedo-boat attack.	.....	Breech piece forms jacket for 19.88 inches.
5.7cm, 2.24 inches, 25 calibers	For flank defense of ditches and field guns.	.....	Breech piece forms jacket for 15.24 inches.
5.7cm, 2.24 inches, 30 calibers	For field guns and flank defense.	.....	Breech piece forms jacket for 27.55 inches.
5.7cm, 2.24 inches, 40 calibers	For naval mounts.....	.....	Breech piece forms jacket for 36.6 inches.
7.5cm, 2.95 inches, 25 calibers	For casemate mountings.	.....	Breech piece forms jacket for 26.5 inches.
7.5cm, 2.95 inches, 30 calibers	For field mountings	.....	Breech piece forms jacket for 27.76 inches.
8cm, 3.15 inches, 30 calibers..	.....do	.....	Breech piece forms jacket for 36.22 inches.
8.2cm, 3.23 inches, 35 calibers	For ships mounting	.....	The gun consists of jacket shrunk on barrel and strengthened by rings.
Howitzers:			
12cm, 4.72 inches, 12 calibers.	Howitzer for field mountings.	.....	One piece of forged crucible steel.
12cm, 4.72 inches, 13 calibers.	Howitzer	.....	.....

The Gruson system of quick-fire guns—Continued.

Kind of gun.	Length in calibers.	Length of gun.	Length of bore.	Length of rifled part.	Diameter over lands.	Diameter in the grooves.	Number of grooves.	Kind of grooves.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*		
3.7cm, 1.46 inches, 23 calibers	23.5	34.31	29.19	24.69	1.46	1.49	12	Parallel.
3.7cm, 1.46 inches, 30 calibers	30.5	44.45	39.3	33.06	1.46	1.47	18	Do.
4.7cm, 1.85 inches, 30 calibers	30.0	55.5	49.8	40.02	1.85	1.88	24	Do.
4.7cm, 1.85 inches, 40 calibers	40.0	74.02	68.31	55.37	1.85	1.88	24	Do.
5.3cm, 2.09 inches, 24 calibers	24.5	51.26	44.09	35.57	2.09	2.1	24	Do.
5.3cm, 2.09 inches, 30 calibers	30.4	63.58	56.4	47.03	2.09	2.1	24	Do.
5.3cm, 2.09 inches, 39 calibers	39.1	81.7	73.03	59.65	2.09	2.1	24	Do.
5.7cm, 2.24 inches, 25 calibers	25.6	57.4	50.1	37.75	2.24	2.25	24	Do.
5.7cm, 2.24 inches, 30 calibers	30.0	67.3	59.9	47.5	2.24	2.25	24	Do.
5.7cm, 2.24 inches, 40 calibers	40.0	89.76	82.28	65.8	2.24	2.25	.....	Do.
7.5cm, 2.95 inches, 25 calibers	25.3	74.8	66.34	49.74	2.95	3.03	24	Wedge-shaped at muzzle.
7 5cm, 2.95 inches, 30 calibers	30.0	88.58	80.12	63.62	2.95	3.03	.....	Wedge-shaped.
8cm, 3.15 inches, 30 calibers..	30.0	94.5	85.24	69.66	3.15	3.23	.....	Wedge-shaped at muzzle.
8.2cm, 3.23 inches, 35 calibers	35.0	113	103.74	84.40	3.23	3.33	.....	Do.
Howitzers:								
12cm, 4.72 inches, 12 calibers.	11.7	55.39	46.71	41.46	4.72	4.83	24	Parallel.
12cm, 4.72 inches, 13 calibers.	12.9	61.04	52.76	47.40	4.72	4.82	.....	Do.

Kind of gun.	Breadth of lands.	Kind of rifling.	Length of one complete turn of rifling.	Cubic contents of powder chamber of empty cartridge case.	Weight of gun with breech mechanism.	Weight of breech mechanism.	Weight of shell.
	Inch.		*Calibers*	*Cu. in.*	*Pounds.*	*Pounds.*	
3.7cm, 1.46 inches, 23 calibers	0.06	Constant, with left-handed twist.	29.9	4.557	81.57	11.02	15.87 oz.
3.7cm, 1.46 inches, 30 calibers	0.058	Increasing right-handed.	150 to 30	8.54	101.4	11.02	1.54 lbs.
4.7cm, 1.85 inches, 30 calibers	0.07	....do	150 to 30	21.05	264.55	26.46	3.3 lbs.
4.7cm, 1.85 inches, 40 calibers	0.067	Increasing and constant right-handed.	150 to 30	31.86	359.35	33.069	.....
5.3cm, 2.09 inches, 24 calibers	0.07	Increasing right-handed.	150 to 30	21.17	313.05	29.7	4.4 lbs.
5.3cm, 2.09 inches, 30 calibers	0.07	Increasing and constant right-handed.	150 to 30	21.17	375	30	4.4 lbs.
5.3cm, 2.09 inches, 39 calibers	0.067	....do	165 to 30	45.16	640	42	4.4 lbs.
5.7cm, 2.24 inches, 25 calibers	0.07	Increasing right-handed.	150 to 30	38.14	396	33	5.99 lbs.
5.7cm, 2.24 inches, 30 calibers	0.07	Increasing and constant right-handed.	150 to 30	40	474	33	5.99 lbs.
5.7cm, 2.24 inches, 40 calibers	0.07	....do	150 to 30	58.22	616	33	5.99 lbs.
7.5cm, 2.95 inches, 25 calibers	0.15	....do	150 to 30	102	759	53	13.23 lbs.
7.5cm, 2.95 inches, 30 calibers	0.15	....do	150 to 30	102	794	53	15.4 lbs.
8cm, 3.15 inches, 30 calibers .	0.168	....do	150 to 25	118.94	992	55	15.43 lbs.
8.2cm, 3.23 inches, 35 calibers	0.16	....do	150 to 30	159.15	1,324	70.55	a15.43 lbs
Howitzers:							
12cm, 4.72 inches, 12 calibers.	0.157	Increasing right-handed.	135 to 25	59.5	946	83.78	36.16 lbs.
12cm, 4.72 inches, 13 calibers.	0.157	....do	150 to 25	59.5	1,102	75	36.16 lbs.

a Armor piercing.

The Gruson system of quick-fire guns—Continued.

Kind of gun.	Charge of powder.	Kind of powder.	Diameter of grain.	Ratio of charge to weight of projectile.	Muzzle velocity, feet per second.	Actual energy at muzzle.	Actual energy per pound of charge.	Actual energy per ton of weight of gun.
			Inch.			*Ft. tons.*	*Ft. tons.*	*Ft. tons.*
3.7cm, 1.46 inches, 23 calibers	0.95 oz.	Smokeless c. 89	0.039	1 to 16.6	1,443.6	14.34	529.56	387.48
3.7cm, 1.46 inches, 30 calibers	1.4 oz.	...do	.04	1 to 17.5	1,410.79	21.3	241.7	469.04
4.7cm, 1.85 inches, 30 calibers	5.29 oz.	Smokeless c. 87	.06	1 to 10	.....	.....	.....	.....
4.7cm, 1.85 inches, 40 calibers	7.76 oz.	Smokeless c. 89	.079	1 to 6.8	2,036.00	94.9	195.7	590.4
5.3cm, 2.09 inches, 24 calibers	4.23 oz.	...do	.05	1 to 16.6	1,460.00	65.19	246.00	465.76
5.3cm, 2.09 inches, 30 calibers	4.23 oz.	...do	.05	1 to 16.6	1,494.00	68.16	256.8	407.00
5.3cm, 2.09 inches, 39 calibers	9.5 oz.	...do	.079	1 to 7.4	2,100.00	135.00	225.8	472.00
5.7cm, 2.24 inches, 25 calibers	8.11 oz.	...do	.079	1 to 11.8	1,575.00	103.00	203.00	584.00
5.7cm, 2.24 inches, 30 calibers	8.11 oz.	...do	.079	1 to 11.8	1,640.00	112.00	221.00	528.00
5.7cm, 2.24 inches, 40 calibers	14.1 oz.	...do	.079	1 to 6.8	2,100.00	183.00	207.00	666.00
7.5cm, 2.95 inches, 25 calibers	1.54 lbs.	...do	.16	1 to 8.6	1,722.00	272.00	176.00	800.00
7.5cm, 2.95 inches, 30 calibers	1.54 lbs.	...do	.16	1 to 10	1,641.00	287.7	186.3	810.16
8cm, 3.15 inches, 30 calibers	2.09 lbs.	...do	.2	1 to 7.4	1,903.00	387.00	251.00	876.00
8.2cm, 3.23 inches, 35 calibers	2.65 lbs.	...do	.197	1 to 5.8	2,166.00	537.7	203.08	902.00
Howitzers:								
12cm, 4.72 inches, 12 calibers.	12.7 oz.	...do	.058	1 to 45.5	984.3	242.9	306.06	574.00
12cm, 4.72 inches, 13 calibers.	12.7 oz.	...do	.06	1 to 45.5	991.00	246.15	310.13	498.6

Kind of gun.	Gas pressure (tons per square inch).	Number of shots fired per minute.	Total weight of shell fired per minute.	Weight of shell per ton of gun weight.	Case shot—number of bullets per minute.	Total actual energy of shell per minute.	Kinds of projectiles used.
			Pounds.			*Ft. ton*	
3.7cm, 1.46 inches, 23 calibers	9.5	a40 to 45	44.09	1.2 lbs.	945	645.8	Cast-iron, shell 2.5 calibers long, and case shot.
3.7cm, 1.46 inches, 30 calibers	12.7	40 to 45	69.4	0.68 lbs.	1,710	958	Cast-iron, common, shell and case shot.
4.7cm, 1.85 inches, 30 calibers	.....	.....	.....	.....	.....	.....	Cast-iron, ring shell, and case shot.
4.7cm, 1.85 inches, 40 calibers	13.3	35 to 40	132.28	.37 lbs.	3,800	3,797.3	.....
5.3cm, 2.09 inches, 24 calibers	.....	40 to 45	198.4	.634 lbs.	3,690	2,933.7	.....
5.3cm, 2.09 inches, 30 calibers	12.7	25 to 30	132.00	.35 lbs.	3,150	.....	Same ammunition as for 2.09, 24 caliber.
5.3cm, 2.09 inches, 39 calibers	.....	25 to 30	132.00	.207 lbs.	.....	4,044	.....
5.7cm, 2.24 inches, 25 calibers	12.7	40 to 45	269.00	1.5 lbs.	.....	4,643	.....
5.7cm, 2.24 inches, 30 calibers	12.7	30 to 45	210.00	15.6 oz.	8,400	3,917	.....
5.7cm, 2.24 inches, 40 calibers	14.03	30 to 35	210.00	12.0 oz.	.....	6,417	.....
7.5cm, 2.95 inches, 25 calibers	12.6	20 to 25	330.00	15 34 oz.	5,100	6,908	.....
7.5cm, 2.95 inches, 30 calibers	12.7	10 to 15	231.5	10.27 oz.	3,060	4,315.6	.....
8cm, 3.15 inches, 30 calibers	12.7	8 to 12	185.2	6.6 oz.	2,520	4,649	.....
8.2cm, 3.23 inches, 35 calibers	13.84	20 to 25	385.81	10.19 oz.	.....	1,345.6	.....
Howitzers:							
12cm, 4.72 inches, 12 calibers.	9.44	8 to 12	433.87	1.018 lbs.	.....	2,915.01	.....
12cm, 4.72 inches, 13 calibers.	9.53	10 to 15	542.33	1.09 lbs.	.....	3,692.2	.....

a From cone mount.

The Gruson system of quick-fire guns—Continued.

Kind of gun.	Cartridge cases.	Weight of case with detonator.	Weight of charge of powder.	Shell, cast iron, common.			
				Length in calibers.	Effective fragments on bursting in exploding box.	Weight of empty shell.	Weight of bursting charge.
							Ounces.
3.7cm, 1.46 inches, 23 calibers.	Drawn brass	5.29 oz.	1 oz.	2.5	18	13.5 oz.	0.9
3.7cm, 1.46 inches, 30 calibers.	Solid drawn brass.	6.7 oz.	1.4 oz.	3.5	20	1.37 lbs.	1.23
4.7cm, 1.85 inches, 30 calibers.	....do	12.34 oz.	5.29 oz.	3.5	35	3.003 lbs.	2.01
4.7cm, 1 85 inches, 40 calibers	Drawn brass	1.32 lbs.	7.76 oz.	3.5	35	3 lbs.	2.01
5.3cm, 2.09 inches, 24 calibers.	....do	13.26 oz.	4.23 oz.	3.2	.....	4 lbs.	3.5
5.3cm, 2.09 inches, 30 calibers.	....do	13.26 oz.	4.23 oz.	3.2	.....	4 lbs.	3.5
5.3cm, 2.09 inches, 39 calibers.	....do	1.9 lbs.	9.5 oz.	3.2	.....	4 lbs.	3.53
5.7cm, 2.24 inches, 25 calibers.	....do	1.6 lbs.	8.1 oz.	3.6	.....	5.6 lbs.	3.17
5.7cm, 2.24 inches, 30 calibers.	....do	1.6 lbs.	1.6 lbs.	3.6	.....	5.6 lbs.	3.17
5.7cm, 2.24 inches, 40 calibers.	....do	2.5 lbs.	14.1 oz.	3.36	.....	.....	.....
7.5cm, 2.95 inches, 25 calibers.	....do	3.7 lbs.	1.54 lbs.	3.3	54	12.72 lbs.	5.36
7.5cm, 2.95 inches, 30 calibers.	.....	3.7 lbs.	1.54 lbs.	3.8	60	14.84 lbs.	6.24
8cm, 3.15 inches, 30 calibers..	.....	3.63 lbs.	2.09 lbs.	3.2	62	14.77 lbs.	7.89
8.2cm, 3.23 inches, 35 calibers.	Drawn brass	4.56 lbs.	2.65 lbs.	.....	.....	.....	.....
Howitzers:							
12cm, 4.72 inches, 12 calibers.	.....	2.88 lbs.	12.70 oz.	.....	.....	.....	.....
12cm, 4.72 inches, 13 calibers.	.....	2.88 lbs.	12.70 oz.	.....	.....	.....	.....

Kind of gun.	Shell, cast iron, common—Con.			Ring shell.			
	Weight of fuse.	Weight of loaded shell.	Weight of cartridge and shell complete.	Length in calibers.	Number of cast-iron rings.	Number of teeth to each ring.	Weight of empty shell.
	Ounces.		*Pounds.*				*Pounds.*
3.7cm, 1.46 inches, 23 calibers.	1.48	15.87 oz.	1.38	.....	.....	.....	.....
3.7cm, 1.46 inches, 30 calibers.	1.48	1 54 lbs.	2.1	.....	.....	.....	.....
4.7cm, 1.85 inches, 30 calibers.	2.75	3.3 lbs.	4.4	3.5	9	8	3.009
4.7cm, 1.85 inches, 40 calibers.	2.75	3.3 lbs.	5.1	3.5	9	8	3.00
5.3cm, 2.09 inches, 24 calibers.	2.75	4.4 lbs.	5.5	3.2	9	8	4.00
5.3cm, 2.09 inches, 30 calibers.	2.75	4.4 lbs.	5.5	3.2	9	.....	.....
5.3cm, 2.09 inches, 39 calibers.	2.75	4.4 lbs.	6.9	3.2	.....	.....	4.00
5.7cm, 2.24 inches, 25 calibers.	2.75	6 lbs.	8	3.6	.....	.....	5.6
5.7cm, 2.24 inches, 30 calibers.	2.75	6 lbs.	8	3.6	.....	.....	.....
5.7cm, 2.24 inches, 40 calibers.	.....	.....	.....	3.6	.....	.....	.....
7.5cm, 2.95 inches, 25 calibers.	2.75	13.23 lbs.	18.32	3.3	(a)	8	12.73
7.5cm, 2.95 inches, 30 calibers.	2.75	15.43 lbs.	20.64	3.8	b 16	9	14.87
8cm, 3.15 inches, 30 calibers..	2.75	15.43 lbs.	21.15	3.2	c 14	10	14.79
8.2cm, 3.23 inches, 35 calibers.	.....	.....	.....	2.9	d 15	8	14.93
Howitzers:							
12cm, 4.72 inches, 12 calibers	.....	.....	.....	2.6	e 15	12	34.06
12cm, 4.72 inches, 13 calibers	.....	.....	.....	2.6	e 15	12	.06

a 114 effective pieces on bursting.
b 146 effective pieces.
c 145 pieces on bursting.
d 150 pieces on bursting.
e 120 pieces.

The Gruson system of quick-fire guns—Continued.

Kind of gun.	Ring shell—Cont'd.				Shrapnel.		
	Weight of bursting charge.	Weight of fuse.	Weight of loaded shell.	Weight of cartridge and shell complete.	Length in calibers.	Body material.	Number of hard lead bullets.
	Ounces.	*Ounces.*	*Pounds.*	*Pounds.*			
3.7cm, 1.46 inches, 23 calibers	.....	.....	.....	.....	.....	.....	.....
3.7cm, 1.46 inches, 30 calibers	.....	.....	.....	.....	.....	.....	.....
4.7cm, 1.85 inches, 30 calibers	2.01	2.75	3.3	4.4	.....	.....	.....
4.7cm, 1.85 inches, 40 calibers	2.01	2.75	3.3	5.1	.....	.....	.....
5.3cm, 2.09 inches, 24 calibers	3.5	2.75	4.4	5.5	3.2	.....	.....
5.3cm, 2.09 inches, 30 calibers	3.5	2.75	4.4	5.5	3.2	.....	.....
5.3cm, 2.09 inches, 39 calibers	3.53	2.75	4.4	6.9	.....	.....	.....
5.7cm, 2.24 inches, 25 calibers	3.17	2.75	6.0	8.0	3.6	.....	.....
5.7cm, 2.24 inches, 30 calibers	3.17	2.75	6.0	8.0	3.6	.....	.....
5.7cm, 2.24 inches, 40 calibers	.....	.....	.....	.....	.....	.....	.....
7.5cm, 2.95 inches, 25 calibers	5.19	2.75	13.23	18.47	3.3	Steel case.	200
7.5cm, 2.95 inches, 30 calibers	6.24	2.75	15.43	20.67	3.8	.....	192
8cm, 3.15 inches, 30 calibers	7.58	2.75	15.43	21.15	3.2	.....	200
8.2cm, 3.23 inches, 35 calibers	5.29	2.75	15.43	22.64	.....	.....	.....
Howitzers:							
12cm, 4.72 inches, 12 calibers	1.75	5.47	36.16	39.84	.....	Steel case.	450
12cm, 4.72 inches, 13 calibers	1.75	5.47	36.16	39.84	.....	...do	450

Kind of gun.	Shrapnel—Continued.						
	Diameter of bullets.	Kind of fuse.	Weight of empty shell case.	Total weight of bullets.	Weight of bursting charge.	Weight of sulphur poured in.	Weight of fuse.
	Inch.		*Pounds.*	*Pounds.*	*Ounces.*		
3.7cm, 1.46 inches, 23 calibers	.....	.....	.....	.....	.....	.....	.....
3.7cm, 1.46 inches, 30 calibers	.....	.....	.....	.....	.....	.....	.....
4.7cm, 1.85 inches, 30 calibers	.....	.....	.....	.....	.....	.....	.....
4.7cm, 1.85 inches, 40 calibers	.....	.....	.....	.....	.....	.....	.....
5.3cm, 2.09 inches, 24 calibers	.....	.....	1.46	1.7	1.06	5.29 oz.	10.05 oz.
5.3cm, 2.09 inches, 30 calibers	.....	.....	1.46	1.7	1.06	5.29 oz.	10.05 oz.
5.3cm, 2.09 inches, 39 calibers	.....	.....	.....	.....	.....	.....	.....
5.7cm, 2.24 inches, 25 calibers	.....	.....	2.68	1.97	0.78	4.23 oz.	12.7 oz.
5.7cm, 2.24 inches, 30 calibers	.....	.....	2.68	1.97	0.78	4.23 oz.	12.7 oz.
5.7cm, 2.24 inches, 40 calibers	.....	.....	.....	.....	.....	.....	.....
7.5cm, 2.95 inches, 25 calibers	0.51	Combination.	5.95	5.07	2.12	7.06 oz.	1.29 lbs.
7.5cm, 2.95 inches, 30 calibers	.53	...do	7.27	5.73	2.12	9.88 oz.	1.29 lbs.
8cm, 3.15 inches, 30 calibers	.527	...do	7.28	5.73	2.12	9.88 oz.	1.29 lbs.
8.2cm, 3.23 inches, 35 calibers	.....	.....	.....	.....	.....	.....	.....
Howitzers:							
12cm, 4.72 inches, 12 calibers.	.57	Combination.	14.07	13.83	6.35	1.65 lbs.	2.43 lbs.
12cm, 4.72 inches, 13 calibers.	.57	...do	14.07	13.83	6.35	1.65 lbs.	2.43 lbs.

The Gruson system of quick-fire guns—Continued.

Kind of gun.	Shrapnel—Continued.			Case shot.	
	Weight of disc and tube.	Weight of shrapnel loaded.	Weight of complete cartridge and shrapnel.	Construction of.	Number of pressed hardened lead bullets.
		Pounds.	*Pounds.*		
3.7cm, 1.46 inches, 23 calibers..	.....	.....	.....	Body of sheet zinc; the head is soldered to body before and base after filling.	18
3.7cm, 1.46 inches, 30 calibers..	.....	.....	.....	....do.....	35
4.7cm, 1.85 inches, 30 calibers..	.....	.....	.....	Casing of sheet zinc, strengthened internally by sheet of steel in 3 segments; conical head soldered on.	94
4.7cm, 1.85 inches, 40 calibers..	.....	.....	.....	.....	.....
5.3cm, 2.09 inches, 24 calibers..	2.65 oz.	4.4	5.5	.....	.....
5.3cm, 2.09 inches, 30 calibers..	2.65 oz.	4.4	5.5	.....	.....
5.3cm, 2.09 inches, 39 calibers..	.....	.....	.....	.....	.....
5.7cm, 2.24 inches, 25 calibers..	3.14 oz.	6.0	8.0	.....	.....
5.7cm, 2.24 inches, 30 calibers..	3.14 oz.	6.0	8.0	.....	.....
5.7cm, 2.24 inches, 40 calibers..	.....	.....	.....	.....	.....
7.5cm, 2.95 inches, 25 calibers..	5.5 oz.	13.23	18.47	.....	204
7.5cm, 2.95 inches, 30 calibers..	6.17 oz.	15.4	20.6	.....	204
8cm, 3.15 inches, 30 calibers ...	6.17 oz.	15.43	21.15	.....	210
8.2cm, 3.23 inches, 35 calibers..	.....	.....	.....	.....	.....
Howitzers:					
12cm, 4.72 inches, 12 calibers.	1.73 lbs.	36.08	39.70	.....	.....
12cm, 4.72 inches, 13 calibers.	1.73 lbs.	36.08	39.70	.....	.....

Kind of gun.	Case shot.						
	Diameter of bullets.	Total weight of bullets.	Weight of complete case shot.	Weight of cartridge and case shot complete.	Charge of powder used with case.		
					Steel armor-piercing shell (length in calibers).	Weight of shell.	Weight of burster.
	Inch.		*Pounds.*	*Pounds.*		*Pounds.*	*Ounces.*
3.7cm, 1.46 inches, 23 calibers ..	0.6	14 oz.	1.1	1.49	.....	.....	.....
3.7cm, 1.46 inches, 30 calibers ..	.55	1.24 lbs.	1.87	2.44	.....	.....	.....
4.7cm, 1.85 inches, 30 calibers ..	.55	3 lbs.	4.18	5.28	.....	.....	.....
4.7cm, 1.85 inches, 40 calibers ..	.....	.....	.....	.....	3.5	3.3	1.06
5.3cm, 2.09 inches, 24 calibers ..	.....	3.6 lbs.	4.62	5.7	.....	.....	.....
5.3cm, 2.09 inches, 30 calibers ..	.....	3.6 lbs.	4.62	5.7	.....	.....	.....
5.3cm, 2.09 inches, 39 calibers ..	.....	.....	.....	.....	.....	4.4	1.06
5.7cm, 2.24 inches, 25 calibers ..	.....	6.5 lbs.	8.4	10.5	.....	.....	.....
5.7cm, 2.24 inches, 30 calibers ..	.....	6.5 lbs.	8.4	10.5	.....	.....	.....
5.7cm, 2.24 inches, 40 calibers .	.....	.....	.....	.....	3.4	5.98	2.12
7.5cm, 2.95 inches, 25 calibers ..	.67	11.7 lbs.	15.87	21.12	.....	.....	.....
7.5cm, 2.95 inches, 30 calibers ..	.67	11.7 lbs.	15.87	21.12	.....	.....	.....
8cm, 3.15 inches, 30 calibers....	.67	12.04 lbs.	16.09	21.15	.....	.....	.....
8.2cm, 3.23 inches, 35 calibers ..	.....	.....	.....	.....	2.9	15.43	3.53
Howitzers:							
12cm, 4.72 inches, 12 calibers.	.....	.....	.....	.....	.....	.....	.....
12cm, 4.72 inches, 13 calibers.	.....	.....	.....	.....	.....	.....	.....

The Gruson system quick-fire guns are made of crucible steel which must bear a maximum strain of 35.5 tons per square inch, have an extension of at least 15 per cent, and a minimum elastic limit of 16.5 tons per square inch. The breech mechanism is the vertical wedge worked by a lever on the right side of gun. The cocking of the striker is effected by the downward movement of the block. The block is cut through at the upper part to facilitate the placing of charge.

The system may be fired by lanyard (in the field gun) and by trigger (in the shielded mountings). In very rapid fire the closing of the block fires the gun.

The Gruson system.

	3.7cm, 1.46 inches, 23 cal.	3.7cm, 1.46 inches, 30 cal.	4.7cm, 1.85 inches, 30 caliber.	4.7cm, 1.85 inches, 40 caliber.	5.3cm, 2.09 inches, 24 cal. *a*	5.3cm, 2.09 inches, 30 cal.
Movable shielded mountings *b*:						
Weight shielded mountings.....lbs..	3,089	.....	.....	.....	5,291	.....
Weight of shield..do..	1,102.3	.....	.....	.....	1,543.2	.....
Elevation.....deg..	10	.....	.....	.....	10	.....
Depression .....do..	5	.....	.....	.....	5	.....
Gun detachment.men..	2	.....	.....	.....	2	.....
Traversing angle.deg..	360	.....	.....	.....	360	.....
Weight of limber..lbs..	.....	.....	.....	.....	1,543.2	.....
				Ships' mounting.		
Cone mounting *c*.....do..	.....	.....	771.6	2,314.8	.....	.....
				With shield.		
Weight of upper part, pounds.....	.....	.....	330.7	1,432.99	.....	.....
Weight of cone....lbs..	.....	.....	440.9	881.84	.....	.....
Height of piece above horizontal plane.....	.....	.....	3.9 ft.	3.937 ft.	.....	.....
Elevation.....deg..	.....	.....	15	15	.....	.....
Depression .....do..	.....	.....	10	8	.....	.....
Traversing angle..do..	.....	.....	30	360	.....	.....
Gun crew.....men..	.....	.....	2	2	.....	.....
Embrasure mounting *d*:						
Weight of embrasure mounting .....lbs..	.....	.....	.....	.....	551.1	.....
Weight of embrasure shield.....pounds..	.....	.....	.....	.....	2,645.5	.....
Angle of elevation.deg..	.....	.....	.....	.....	20	.....
Angle of depression deg.....	.....	.....	.....	.....	15	.....
Traversing angle.deg..	.....	.....	.....	.....	40	.....
Gun crew.....men..	.....	.....	.....	.....	2	.....
Boat mounting, weight of, pounds.....	.....	198.4	.....	.....	.....	.....
Weight of upper part, pounds.....	.....	55.11	.....	.....	.....	.....
Weight of column.lbs..	.....	143.3	.....	.....	.....	.....
Height of axis of bore above horizon.. feet..	.....	1.97	.....	.....	.....	.....
Elevation.....deg..	.....	15	.....	.....	.....	.....
Depression .....do..	.....	15	.....	.....	.....	.....
Traversing angle ..do..	.....	360	.....	.....	.....	.....
Gun crew.....men..	.....	2	.....	.....	.....	.....
Mountain-gun carriage, weight of .....pounds..	.....	286	.....	.....	.....	.....
Height of axis of gun above horizon..feet..	.....	26	.....	.....	.....	.....
Elevation.....deg..	.....	25	.....	.....	.....	.....
Depression.....do..	.....	15	.....	.....	.....	.....
Training .....do..	.....	15	.....	.....	.....	.....
Gun crew.....men..	.....	2	.....	.....	.....	.....
Field mounting *f*:						
Weight of carriage exclusive of gun...lbs..	.....	.....	1,036.16	.....	.....	1,102.3
Weight of gun.....do..	.....	.....	264.55	.....	.....	374.78
Elevation.....deg..	.....	.....	15	.....	.....	15
Depression .....do..	.....	.....	10	.....	.....	14
Traversing of carriage on its pivot.....deg..	.....	.....	15	.....	.....	15

a With guns exclusive of carriage.

b The Gruson movable shielded carriage consists of a steel cylinder with bottom and doors, and is closed at the top by a revolving shield plate. A small embrasure is formed in the shield, close to the inside of which the support for the trunnions is placed and fixed. The gunner sits inside the cylinder, around the walls of which 100 rounds of ammunition are placed, across a saddle, and trains the shield and gun by a hand wheel, whilst the elevation is given by an ordinary screw. The carriage is transported on a special axle. When in position, it is sunk or built up to the level of the movable shield.

c The ships' mounting consists of a frame or under part, provided with guides for the recoil of the carriage proper, and which can be turned upon a pivot cone. The frame is of one steel casting for higher calibers and of bronze for lower. It embraces the upper part of pivot cone with a sort of bell-shaped base, and is capable of turning upon the latter. To prevent the bell-shaped part from jumping off the cone when the gun is fired, two holding-down hooks are screwed upon it. These engage in a circular groove on the surface of the cone. The recoil is checked by a hydraulic cylinder. The gun is returned to battery by a spring. A shield to protect the gunners from musketry fire is attached to the carriage.

d The casemate cone mounting consists of a carriage proper, which revolves without recoil upon a cone. The carriage is cast out of steel. It turns upon a bed riveted to the cone about a hollow pivot bolt. The cone is made of steel plates riveted together. It is made fast to a platform, so as to do away with recoil. In the embrasure casemate mount the gun rests in a spherical carriage, which revolves around its vertical axis, and which is fixed in the casemate shield in such a way that it approximately closes up the embrasure of the latter.

of gun carriages.

5.3cm, 2.09 inches, 39 cal.	5.7cm, 2.24 inches, 25 cal.	5.7cm, 2.24 inches, 30 cal.	5.7cm, 2.24 inches, 40 caliber.	7.5cm, 2.95 inches, 25 cal.	7.5cm, 2.95 inches, 30 cal.	8cm, 3.15 inches, 30 cal.	8.2cm, 3.23 inches, 35 cal.
.....	5,060	.....	.....	.....	.....	.....	.....
.....	1,320	.....	.....	.....	.....	.....	.....
.....	10	.....	.....	.....	.....	.....	.....
.....	5	.....	.....	.....	.....	.....	.....
.....	2	.....	.....	.....	.....	.....	.....
.....	360	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
Ships' mounting.			Ships' mounting.	With hydraulic brakes.			
Mark 1:	1,650	.....	2,480	1,870	.....	.....	3,660
With shield.			With shield.				
151,236	396	352.74	1,552	924	.....	.....	2,778
903.9	1,254	473.99	935	946	.....	.....	882
50.69 in.	51.1 in.	47.24 in.	47.24	45.28	.....	.....	3.77 ft.
15	15	15	15	12	.....	.....	20
8	10	10	8	5	.....	.....	5
360	30	30	360	30	.....	.....	360
2	2	2	2	2	.....	.....	6
(e)	.....	.....	.....	.....	.....	.....	.....
.....							
.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
.....							
.....	.....	.....	.....	.....	.....	.....	.....

The Cruson system of

	3.7cm, 1.46 inches, 23 cal.	3.7cm, 1.46 inches, 30 cal.	4.7cm, 1.85 inches, 30 caliber.	4.7cm, 1.85 inches, 24 caliber.	5.3cm, 2.09 inches, 24 cal.*a*	5.3cm, 2.09 inches, 30 cal.
Height of axis of gun	.....	.....	47.24 in.	.....	.....	3.77 ft.
Angle of trail.....deg..	.....	.....	34	.....	.....	37
Pressure on trail end..lbs..	.....	.....	99.2	.....	.....	121.25
Amount of recoil on wood platform:						
With brakes applied...	.....	.....	15.75 in.	.....	.....	1.312 ft.
Without brakes.....	.....	.....	43.3 in.	.....	.....	3.609 ft.
Gun detachment.....men..	.....	.....	3	.....	.....	2
Weight of limber without ammunition ....pounds..	.....	.....	1,212.5	.....	.....	1,227.96
Breadth of track of the carriage and limber...inch..	.....	.....	59.96	.....	.....	59.1
Height of wheels.....do..	.....	.....	55.12	.....	.....	55.1
Width of wheel tires...do..	.....	.....	2.68	.....	.....	2.76
Weight of field piece without ammunition.....lbs..	.....	.....	2,513.24	.....	.....	2,809.4
Weight of field piece with ammunition .....lbs..	.....	.....	3,031.3	.....	.....	3.218
Ratio between weight on front and rear axles(about)	.....	.....	1 to 0.85	.....	.....	1 to 0.8
Draft .....horses..	.....	.....	4	.....	.....	4
Load per horse ...pounds..	.....	.....	756.17	.....	.....	804,68
Rounds of ammunition carried in limber	.....	.....	94	.....	.....	.....
Disappearing shielded mountings*b*.....pounds..	.....	.....	.....	.....	.....	.....
Weight of, with glacis armor.....pounds..	.....	.....	.....	.....	27,557.5	.....
Elevation...., ...deg..	.....	.....	.....	.....	10	.....
Depression .....do..	.....	.....	.....	.....	5	.....
Traversing .....do..	.....	.....	.....	.....	360	.....
Gun detachment. men..	.....	.....	.....	.....	2	.....

a With guns exclusive of carriage.

b The disappearing shielded mounting consists of a shield roof supported by a pillar, which rests on a balance lever, at the end of which is a counterweight. The rise and fall of the shield is effected by the movement of the balance lever. The shield moves around on a flat collar on which it is balanced. The gunner sits crosswise on a saddle and trains the shield with his feet by means of a treadle and coned pinions. The recoil of the gun is absorbed by the shield, which recoils against the glacis armor ring when the gun is fired, the center of gravity being so arranged that the mounting immediately resumes its vertical position on the collar. The gun is withdrawn before lowering the roof shield. The interior of the mounting contains 700 rounds of ammunition.

gun carriages—Continued.

5.3cm, 2.09 inches, 39 cal.	5.7cm, 2.24 inches, 25 cal.	5.7cm, 2.24 inches, 30 cal.	5.7cm, 2.24 inches, 40 caliber.	7.5cm, 2.95 inches, 25 cal.	7.5cm, 2.95 inches, 30 cal.	8cm, 3.15 inches, 30 cal.	8.2cm, 3.23 inches, 35 cal.
.....	.....	47.24 in.	.....	.....	3.77 ft.	3.77 ft.	3.89 ft.
.....	.....	34	.....	.....	37	36	54
.....	.....	127.87	.....	.....	154	199	309
.....	.....	14.96 in.	.....	.....	39 in.	51 in.	39 in.
.....	.....	40.94 in.	.....	.....	150 in.	177 in.	158 in.
.....	.....	3	.....	.....	3	3	3
.....	.....	1,154.4	.....	.....	.....	1,268	1,246
.....	.....	.....	.....	.....	59.06	59.06	59.06
.....	.....	55.12	.....	.....	55.12	55.22	49.41
.....	.....	2.76	.....	.....	2.76	2.76	3.23
.....	.....	2,761	.....	.....	3,197	3,472	3,624
.....	.....	3,304	.....	.....	4,023	4,057	4,422
.....	.....	1:1	.....	.....	1:1	1:0.9	1 to
.....	.....	4	.....	.....	6	6	6
.....	.....	825	.....	.....	672.4	677	736
.....	.....	.....	.....	.....	.....	.....	.....
.....	32,340	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
.....	16	.....	.....	.....	.....	.....	.....
.....	15	.....	.....	.....	.....	.....	.....
.....	360	.....	.....	.....	.....	.....	.....
.....	2	.....	.....	.....	.....	.....	.....

Howitzers.

12cm.; 4.72 inches.; 12 calibers.

12cm.; 4.72 inches.; 13 calibers.

Shielded mounting without gun, 38,580 pounds; weight of glacis armor, 13,228 pounds; elevation, 35 degrees; depression, 5 degrees; traverse, 360; gun crew, 2 men.

Range table for Gruson quick-firing guns.

[Calculated for a weight of atmosphere 0.0753 pounds to cubic foot.]

Kind of gun.	Projectile.	Muzzle velocity.	Range.	Elevation in degrees and ¼ degree.	Deflection ¼ degree.	Angle of fall, degrees and ¼ degree.	Time of flight.	¼ degree throws the projectile up, down, or to the side, about.	¼ degree alters the range about.	Trial velocity per second.	50 per cent strikes a target high.	50 per cent strikes a target broad.	50 per cent strikes a target long.	Graduation that shell may burst 164 feet in front of object.	Case shot.	
															Distance.	Point of object to be aimed at with rear sight entirely lowered.
		F. s.	*Yards.*	°	°	°	*Secs.*	*Feet.*	*Yds.*		*Feet.*	*Feet.*	*Feet.*	*Seconds.*	*Yards.*	
3.7cm, 1.46 in., 23 cal.	Shell 15.87 oz. weight.	1,444	109	0	8	0^{4}	0 3	0.3	36	1,339	0.3	0.3	46	.....	Up to 109	Foot of object.
			1,422	3^{5}	$10\frac{1}{2}$	5^{1}	4.3	4.6	19	774	4.9	3.9	56	.....	109 to 164	Middle of object.
			2,953	9^{12}	20	15^{14}	10.8	9.8	11	610	.....	11.2	105	.....	267 to 328	Middle of object; aim being taken one finger's breadth above top of rear sight.
3.7cm, 1.46 in., 30 cal.	Shell 1.54 lbs. weight.	1,411	109	0	8	0^{4}	0.3	0.3	36	1,332	.....	.....	.....	.....	Up to 109	Foot of object.
			1,750	4^{1}	11	5^{14}	5.4	5.9	18	756	5.6	3.9	66	.....	164 to 267	Head of object.
			3,828	14^{13}	$19\frac{1}{3}$	27^{14}	15.6	12.5	9	640	.....	14.4	154	.....	267 to 328	Middle of object; aim taken one finger's breadth above top rear sight.
5.3cm, 2.09 in., 24 cal.	Shell 4.4 lbs. weight.	1,460	109	0	8	0^{3}	0.2	0.3	55	1,398	.....	.....	.....	0	.....	
			2,189	4^{15}	$12\frac{1}{2}$	7^{7}	6.7	7.2	18	794	9.8	3.9	79	6.3	.....	
			4,374	15^{6}	23	27^{13}	17.1	14.4	10	643	.....	13.8	177	.....	.....	
5.3cm, 2.09 in., 30 cal.	Shell and shrapnel 4.409 lbs.	1,493	109	0	8	0^{3}	0.2	0.3	.....	1,426	.....	.....	.....	.....	Up to 109	Foot of object.
			2,515	5^{12}	$13\frac{1}{2}$	9^{5}	7.7	8.2	16	761	.....	6.9	85	7.3	109 to 164	Knee height.
															164 to 219	Middle.
			4,921	18^{11}	$27\frac{1}{2}$	34^{11}	20.2	16.4	9	636	.....	23.6	233	.....	219 to 328	Head.
															437 to 547	Middle aim over rear sight as above.
5.3cm, 2.09 in., 39 cal.	Armor-piercing shell 4.41 lbs. weight.	2,100	109	0^{2}	8	0^{1}	0.2	0.3	.....	2,014	.....	.....	.....	.....	.....	
			3,062	4^{9}	$11\frac{1}{2}$	7^{7}	7.5	10.2	23	860	.....	5.9	98	.....	.....	
			6,015	15^{15}	$19\frac{1}{2}$	34^{5}	21.1	20.	12	709	.....	29.2	164	.....	.....	
5.7cm, 2.24 in., 25 cal.	Shell and shrapnel 5.99 lbs. weight.	1,575	109	0	8	0^{3}	0.2	0.3	.....	1,509	.....	.....	.....	0	.....	Same as for 5.3cm, 39 calibers; weight of case 8.38 pounds.
			2,515	4^{13}	$13\frac{1}{2}$	7^{5}	7.1	8.2	19	846	8.9	4.6	69	6.7	.....	
			4,921	14^{12}	$27\frac{1}{2}$	26^{7}	17.9	16.4	12	712	.....	17.4	161	.....	.....	
7.5cm, 2.95 in., 25 cal.	Shell and shrapnel 13.23 lbs. weight.	1,722	109	0	8	0^{3}	0.2	0.3	.....	1,673	.....	.....	.....	0	.....	Same as for 5.3cm, 39 calibers; case shot weighs 15.87 pounds.
			3,062	4^{14}	10	7^{1}	7.6	10.2	26	932	9.5	5.2	82	7.2	.....	
			6,015	14^{12}	$16\frac{1}{2}$	26	19.3	20.	13	745	.....	17.1	144	.....	.....	

8cm, 3.15 in. 30 cal.	Shell 15.43 lbs. weight.	1,903	109	0	8	0^{2}	0.1	0.3	.....	1,847	.....	.....	.....	.....	.....	Same as for 5.3cm, 39 calibers; weight of case 16.1 pounds.
			4,374	7^{4}	$12\frac{1}{2}$	12^{2}	11.5	14.4	22	846	.....	10.2	125	.....	.....	
			8,749	25^{15}	26	58^{6}	32.	28.9	11	820	.....	31.5	177	.....	.....	
8.2cm, 3.23 in., 35 cal.	Armor-piercing shell 15.43 lbs. weight.	2,165	109	0^{3}	8	0^{1}	0.2	0.3	.....	2,103	.....	.....	.....	.....	.....	
			3,828	4^{14}	$11\frac{1}{2}$	8^{1}	8.7	12.5	28	935	.....	6.6	102	.....	.....	
			7,655	18	21	32^{7}	24.8	25.3	13	801	.....	24.9	55	.....	.....	
		Charge.														
		Ounces.														
12cm, 4.72 in., 13 cal. Howitzer.	Shell weight 36.2 lbs.; shrapnel weight 36.2 lbs.	3.88	109	1^{12}	$1\frac{1}{2}$	1^{15}	0.8	0.3	3	384	.....	0.3	.....	.....	.....	
		8.82		0^{7}	$\frac{1}{2}$	0^{8}	0.4		13	761	.....	0.3	20	.....	.....	
		12.7		0^{4}	0	0^{5}	0.3		25	978	.....	0.3	.....	.....	.....	
		8.82	3,281	20^{6}	14	23^{15}	16.1	9.2	7	610	.....	5.6	52	.....	.....	
		12.7		10^{15}	$5\frac{1}{2}$	13^{6}	11.9	10.2	14	732	.....	4.6	39	.....	.....	
		12.7	6,343	34^{8}	17	44	30.6	a11.8 b21.	4	673	.....	22.6	138	.....	.....	

a Up or down. *b* To side.

General data of Hotchkiss rapid-firing guns.

	37mm short 1-pdr.	37mm light 1-pdr.	37mm long 2-pdr.	42mm mountain 2-pdr.	47mm short 2½-pdr.	47mm light 2½-pdr.	47mm medium 3-pdr.	47mm long 3-pdr.	53mm 3½-pdr.	57mm short 6-pdr.	57mm light 6-pdr.	57mm long 6-pdr.	65mm 9-pdr.	75mm field 12-pdr.	76mm mountain 12-pdr.	76mm light 10-pdr.	76mm long 14-pdr.	100mm 33-pdr.	120mm light 55-pdr.	120mm long 55-pdr.	155mm 100-pdr.
Weight of gun ..... kilos..	33	48	120	55	100	120	216	220	120	230	236	365	600	350	98	160	880	1,650	2,150	3,320	5,500
Length of bore ..... in calibers..	20	35	42	25	25	30	35	40	27	22	30	40	43	26	13	21.5	44	42	37	43	36
Travel of projectile in bore ..... dm..	6.68	12.23	13.04	9.46	10.76	13.11	14.25	15.40	12.79	10.83	15.24	20.18	24.02	17.00	9.20	15.20	27.65	35.00	37.50	42.00	76.60
Length of gun ..... mm..	842	1,397	1,690	1,170	1,325	1,557	1,812	2,048	1,594	1,460	1,895	2,480	3,025	2,144	1,133	1,768	3,562	4,413	4,633	5,345	5,930
Rifling:																					
Number of grooves	12	12	12	10	20	20	20	20	24	24	24	24	26	28	24	24	28	30	36	36	42
Angle of rifling	6°	6°	6°	6°	5°40′	5°40′	5°40′	5°40′	6°20′	1°-6°	1°-6°	1°-6°	0°-6°5′	6°30′	7°	6°	1°-7°	0°-7°	3°-7°	3°-7°	3°-7°
Width of bands ..... mm..	1.5	1.5	1.5	4	2	2	2	2	1.7	1.86	1.86	1.86	1.95	2	2.97	3	2	2.5	2.5	2.5	3
Depth of grooves ..... do...	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.6	0.5	0.65	0.4	0.5	0.6	1.2	1.2	1.25
Weight of breechblock ..... kilos..	4	4	12	4.2	12	12	17.5	17.5	17.5	22	22	27	33	29	10	12	37	60	70	80	90
Weight of projectile ..... do...	0.455	0.455	0.850	0.880	1.075	1.075	1.500	1.500	1.630	2.720	2.720	2.720	4.000	5.440	5.450	4.550	6.400	15.000	25.000	25.000	45.000
Ratio of weight to spherical shot of same diameter	2.45	2.45	4.60	3.15	2.82	2.82	4.00	4.00	2.90	4.00	4.00	4.00	4.00	3.43	3.27	2.72	3.85	4.00	3.83	3.83	3.20
For black powders:																					
Charge of powder ..... kilos..	0.080	0.080	0.320	0.175	0.205	0.205	0.475	0.800	0.360	0.630	0.630	0.920	1.650	1.200	0.375	0.525	3.200	6.000	9.000	13.500	22.000
Initial velocity of projectile ..... meters..	402	435	600	445	425	450	500	610	450	450	460	600	620	458	265	365	620	600	600	675	650
Pressure at breech ..... kilos per square cm..	1,200	1,200	2,300	.....	.....	.....	1,700	2,300	.....	1,800	1,800	2,550	2,500	1,650	1,050	1,050	2,300	2,450	2,500	2,550	2,500
Muzzle energy $\frac{Pv^2}{2g}$ .. metric tons..	4.12	4.4	15.6	8.80	9.90	11.35	19.11	28.46	17.21	20.07	29.35	49.93	78.41	57.53	19.52	30.90	125.5	275.4	458.7	580.6	769.8
Thickness of plate perforated by steel shell—																					
At muzzle ..... mm..	29	37	87	.....	46	51	.....	105	51	.....	85	129	156	.....	.....	.....	187	250	300	360	.....
At 1,000 metric range ....do...	13	14	38	.....	21	23	.....	50	32	.....	48	78	90	.....	.....	.....	128	189	251	275	.....
At 2,000 metric range ....do...	8	9	23	.....	14	15	.....	31	22	.....	36	48	64	.....	.....	.....	88	143	177	212	.....
For smokeless powders, French BN type:																					
Charge of powder ..... kilos..	0.060	0.060	.....	.....	.....	.....	.....	0.425	.....	.....	.....	0.475	0.850	.....	0.200	.....	1.800	3.100	.....	.....	.....
Initial velocity of projectile ..... meters..	460	508	.....	.....	.....	.....	.....	720	.....	.....	.....	650	700	.....	300	.....	735	677	.....	.....	.....
Pressure at breech ..... kilos per square cm..	1,000	1,000	.....	.....	.....	.....	.....	2,480	.....	.....	.....	2,600	2,550	.....	1,150	.....	2,500	2,400	.....	.....	.....
Muzzle energy $\frac{Pv^2}{2g}$ .. metric tons..	4.91	6.5	.....	.....	.....	.....	.....	39.64	.....	.....	.....	62.8	100.0	.....	.....	.....	176.2	348.0	.....	.....	.....
Thickness of plate perforated by steel shell—																					
At muzzle ..... mm..	38	41	.....	.....	.....	.....	.....	135	.....	.....	.....	143	189	.....	.....	.....	244	301	.....	.....	.....
At 1,000 metric range ....do...	14	15	.....	.....	.....	.....	.....	70	.....	.....	.....	88	120	.....	.....	.....	161	228	.....	.....	.....
At 2,000 metric range ....do...	9	9	.....	.....	.....	.....	.....	38	.....	.....	.....	54	77	.....	.....	.....	111	174	.....	.....	.....
Rapidity of fire...rounds per minute..	25–30	25–30	20–25	8–10	20–25	20–25	15–20	15–20	15–20	15–20	15–20	15–20	15–20	8–10	8–10	8–10	12–15	10–12	10–12	8–10	6–8

Weights and dimensions of ammunition for Hotchkiss rapid-firing guns.

	37mm short 1-pdr., and 37mm light 1-pdr.	37mm long 2-pdr.	42mm mountain 2-pdr.	47mm short 2½-pdr., and 47mm light 2½-pdr.	47mm medium 3-pdr.	47mm long 3-pdr.	53mm 3½-pdr.	57mm short 6-pdr.	57mm light 6-pdr.	57mm long 6-pdr.	65mm 9-pdr.	75mm field 12-pdr.	76mm mountain 12-pdr.	76mm light 10-pdr.	76mm long 14-pdr.	100mm 33-pdr.	120mm light 55-pdr.	120mm long 55-pdr.	155mm 100-pdr.
Steel shell:																			
Total weight ..... kilos..	0.505	0.850	.....	1.115	1.500	1.500	1.630	2.720	2.720	2.720	4.000	.....	.....	.....	6.400	15.000	25.000	25.000	45.000
Weight of bursting charge ..... grams..	15	25	.....	45	50	50	70	115	115	115	145	.....	.....	.....	200	600	820	820	.....
Weight of percussion fuse ..... do...	40	40	.....	65	65	65	65	65	65	65	65	.....	.....	.....	65	65	65	65	65
Common shell:																			
Total weight ..... kilos..	0.455	0.850	0.880	1.075	1.500	1.500	1.630	2.720	2.720	2.720	4.000	5.450	5.450	4.550	6.400	15.000	25.000	25.000	45.000
Weight of bursting charge ..... grams..	22	30	50	45	60	60	70	85	85	85	112	180	180	200	200	520	575	575	1.400
Weight of percussion fuse ..... do...	20	60	55	20	65	65	55	65	65	65	65	65	90	90	65	65	65	65	65
Shrapnel:																			
Total weight ..... kilos..	.....	.....	.....	.....	.....	.....	.....	2.720	2.720	2.720	4.240	5.450	5.450	4.550	6.400	15.000	25.000	25.000	45.000
Weight of bursting charge ..... grams..	.....	.....	.....	.....	.....	.....	.....	45	45	45	55	100	55	75	100	180	465	465	.....
Weight of time and percussion fuse ... do...	.....	.....	.....	.....	.....	.....	.....	290	290	290	290	380	290	290	290	380	380	380	380
Number of balls	.....	.....	.....	.....	.....	.....	.....	40	40	40	55	135	160	.....	165	234	234	234	.....
Number of cast-iron separators	.....	.....	.....	.....	.....	.....	.....	7	7	7	8	9	.....	.....	11	14	13	13	.....
Number of effective fragments	.....	.....	.....	.....	.....	.....	.....	104	104	104	120	195	180	.....	220	325	325	325	.....
Case shot:																			
Total weight ..... kilos..	0.570	0.850	1.280	1.280	1.500	1.500	1.900	3.050	3.050	3.050	4.225	5.450	5.450	4.550	6.400	15.000	25.000	25.000	45.000
Number of balls	28	40	30	30	40	40	58	80	80	80	170	269	138	.....	323	96	170	170	.....
Weight of empty cartridge case:																			
Hotchkiss type ..... kilos..	0.090	0.425	0.150	0.250	0.500	0.600	0.290	0.600	0.600	0.780	1.480	1.120	0.570	0.650	2.200	4.300	5.750	8.500	11.500
Solid drawn type ..... do...	0.137	.....	.....	0.350	0.575	0.675	0.325	0.750	0.750	0.855	1.620	.....	.....	.....	.....	.....	.....	.....	.....
Powder charge:																			
For steel and common shell—																			
Black powder ..... kilos..	0.080	0.320	0.175	0.200	0.475	0.800	0.360	0.630	0.630	0.920	1.650	1.200	0.375	0.520	3.200	6.000	7.800	13.500	22.000
BN smokeless powder ..... do...	0.060	.....	.....	.....	.....	0.425	.....	.....	.....	0.475	0.850	.....	0.200	.....	1.800	3.100	.....	.....	.....
For shrapnel and case shot—																			
Black powder ..... kilos..	0.060	0.320	0.150	0.180	0.475	0.800	0.320	0.600	0.600	0.800	1.200	1.200	0.375	.....	.....	5.000	7.800	.....	22.000
BN smokeless powder ..... do...	0.050	.....	.....	.....	.....	0.425	.....	.....	.....	0.450	.....	.....	0.200	.....	.....	.....	.....	.....	.....
Total weight of cartridge (Hotchkiss) loaded with black powder:																			
Steel shell ..... kilos..	0.675	1.600	.....	1.570	2.490	2.910	2.285	3.960	3.960	4.380	7.150	.....	.....	.....	12.000	25.350	39.800	47.200	79.000
Common shell ..... do...	0.625	1.600	1.210	1.530	2.490	2.910	2.285	3.960	3.960	4.380	7.150	7.800	6.430	5.740	12.000	25.350	39.800	47.200	79.000
Shrapnel ..... do...	.....	.....	.....	.....	.....	.....	.....	3.960	3.960	4.260	6.950	7.800	6.430	5.740	.....	24.350	38.600	.....	79.000
Case shot ..... do...	0.720	1.600	1.580	1.715	2.490	2.910	2.515	4.230	4.230	4.520	7.150	7.800	6.430	5.740	.....	24.350	38.600	.....	79.000
Total weight of cartridge (Hotchkiss) loaded with smokeless powder:																			
Steel shell ..... kilos..	0.655	.....	.....	.....	.....	2.530	.....	.....	.....	3.935	6.350	.....	.....	.....	10.600	22.450	.....	.....	.....
Common shell ..... do...	0.605	.....	.....	.....	.....	2.530	.....	.....	.....	3.935	6.350	.....	6.225	.....	10.600	22.450	.....	.....	.....
Shrapnel ..... do...	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.910	.....	.....	6.225	.....	.....	.....	.....	.....	.....
Case shot ..... do...	0.710	.....	.....	.....	.....	2.530	.....	.....	.....	4.180	6.350	.....	6.225	.....	.....	.....	.....	.....	.....
Total length of complete cartridge (common shell) ..... mm..	167	578	263	235	400	522	310	405	405	481	668	507	357	347	870	1,084	1,067	1,334	1,310

Weights and dimensions of Hotchkiss rapid-firing mountain guns.

		42mm 2-pdr.	76mm 12-pdr.
Weight of gun	kilos..	55	99
Carriage:			
Weight of carriage body	do...	44	94
Weight of wheels	do...	56	56
Diameter of wheels	mm..	950	950
Track of wheels	do...	750	720
Height of trunnions above the ground	do...	700	602
Maximum angles of elevation	degrees..	+15	+20
		− 5	−10
Weight of shafts	kilos..	13	13
Weight of appurtenances	do...	6	10
Average length of recoil at 0° elevation	meters..	1	4
Prairie limber:			
Weight of limber body	kilos..	.....	119
Wheels and shaft same as carriage		.....	.....
Number of ammunition chests carried by limber		.....	4
Number of rounds of ammunition carried by limber		.....	32
Weight of appurtenances	kilos..	.....	14
Total weight with ammunition, etc	do...	.....	457
Ammunition chests:			
Weight of pair of chests, empty	do...	27	28
Number of rounds per chest	do...	42	8
Weight of pair of chests filled	do...	110	130
Weight of pair of chests with tools for saddler and wheelwright	do...	85	85
Weight of pair of chests with forge and farriers' tools	do...	.....	.....
Weight of saddle and harness for gun and carriage	do...	30	31
Weight of saddle and harness for ammunition and stores	do...	26	26

Weights, etc., of Hotchkiss rapid-firing field guns and carriages.

		47mm short 2½-pdr.	47mm light 3-pdr.	57mm light 6-pdr.	57mm field 12-pdr.	80mm field 12-pdr.
Weight of gun	kilos..	100	216	236	350	445
Carriage:						
Weight of carriage with appurtenances	do...	356	530	530	465	475
Diameter of wheels	mm..	1,150	1,430	1,430	1,430	1,430
Weight of 1 wheel	kilos..	45	76	76	76	76
Track of wheels	mm..	1,100	1,500	1,500	1,450	1,500
Height of trunnions above the ground	do...	930	1,085	1,085	965	1,085
Maximum angles of fire	degrees..	+15	+12	+12	+25	+25
		− 5	− 5	− 5	−10	−10
Average length of recoil at 0° elevation	meters..	Nil.	Nil.	Nil.	0.80	1.50
Weight of folding shield (5mm thickness) extra	kilos..	90	115	115	115	115
Limber:						
Weight of limber, empty	do...	395	500	545	500	500
Wheels and track same as carriage		.....	.....	.....	.....	.....
Number of rounds carried by limber		189	90	72	40	32
Weight of limber, equipped, with ammunition	kilos..	700	735	850	820	800
Total weight of gun, carriage, and limber, with ammunition and appurtenances	kilos..	1,156	1,480	1,615	1,635	1,720
Ammunition wagon:						
Limber, same as gun limber		.....	.....	.....	.....	.....
Weight of wagon body, empty	kilos..	.....	750	675	670	670
Wheels and track same as carriage		.....	.....	.....	.....	.....
Total number of rounds carried		.....	270	168	120	96
Total weight of wagon, with ammunition and appurtenances	kilos..	.....	2,010	2,200	2,220	2,135

FIELD CARRIAGE FOR RAPID FIRE.

In order that the property of rapid fire which a gun may possess should be developed in field artillery, it is absolutely necessary that the gun should have no recoil whatever, as otherwise all that is gained in quickness of loading or aiming is more than neutralized by the necessity for moving the gun up into position, and rectifying the aim after each shot. The weights permitted in field guns and carriages are so limited that it is found impossible to give sufficient strength to a car-

riage of a rigid system where high power is developed and recoil is suppressed. The following conditions must be satisfied in any field system claiming high power and rapid fire:

First. The strength of the carriage must be ample to resist the strains imposed.

Second. The weight must be kept within the limits required for great mobility.

Third. Elastic connections must be introduced to reduce the magnitude of the strain increments.

Fourth. The system must possess a means of ground connection that shall totally suppress recoil.

Fifth. Recoil being suppressed, the elastic connections must have but a moderate stiffness in order that the system shall not be upset or violently displaced by the shock of firing.

Sixth. The lack of stiffness or momentary resistance must be compensated for by a considerable length of movement of the semidetached portion, and this requirement demands such an application of means as shall cause the parts to resume a normal position automatically after firing.

Seventh. The elastic connections must be of such a description as will satisfy the demands of campaign service; especially that of rough treatment and neglect.

PLATE XXV.

The Hotchkiss field carriage consists of two distinct parts, a main carriage and a top carriage.

The main carriage is formed of two bracket sides, connected by transoms, bolts, and a trail-plate; a slide for the top carriage; an axle and field wheels. The bracket sides are of steel plate lined with angle steel. The trail-plate is of the ordinary field-carriage pattern, being provided underneath with a stout spade for resisting recoil. The slide is of steel, being provided with small buffers at the front and rear ends; a pivot socket at the front end permits a lateral traverse of about four degrees to the right and left of the center line.

The axle is of steel, firmly bedded in the brackets. The wheels have gun-metal naves and ring tires.

The top carriage is formed of two bracket sides, connected by transoms and held to the slide by stout clips at the bottom edge and by stout steel springs attached diagonally to the slide in such a manner as to efficiently ease the firing strain on the body of the trail, and whilst allowing a good length of recoil to the top carriage, to insure bringing it back to its normal position after firing.

The elevating gear is of the plain screw pattern, seating on the left bracket of the top carriage, and connected with the breech of the gun by an auxiliary piece bolted to the left cheek of the breech. The traverse gear of the slide consists of a screw seated in the brackets of the

main carriage, and carrying a traveler bolted to the under side of the slide. A directing bar is pivoted to the top of the trail plate.

The brake consists of two malleable cast-steel wheel-chocks connected by a steel bar, which in turn is connected to the axletree by two steel bars, the whole forming a pivoting frame-work. When not in use the brake is hooked up under the trail; when in action the frame is dropped, the shoes being pushed under the wheels. In limbering up it is simply necessary to start the carriage forward slightly, when the brake comes free of the wheels, and can be hooked up at once.

A tool-box is fitted between the main carriage brackets to hold the reserve parts and accessories.

THE LIMBER.

PLATE XXVI.

The body of the limber consists of four futchells, a splinter bar, foot board, and platform board.

The outside futchells are of flat steel, the inside ones and the splinter bar being of angle steel; the platform and foot board are of oak. A cast-steel limber hook is riveted between the inside futchells.

A pole for double draft is bedded in the body, having a steel swingletree and steel splinter bars. The steel axle is secured to its bed in three bearings. The wheels are similar to those of the gun carriage.

The limber carries an ammunition-chest made of steel plate. The cartridges are carried in boxes of convenient size for transport by two men. (The 3-pounder box holds twenty-one rounds.) The chest is so arranged that the boxes are drawn out from the rear. The top of the ammunition-chest is fitted with a cushion and side rails for cannoneer seats.

EMBRASURE MOUNT.

This type of mount is designed to fulfill a special object, the gun being required to fight in an embrasure already occupied by a heavy gun. The gun must be kept extremely low, and on this account must be given recoil in order to ease the firing strains; the recoil itself must be limited to the least distance possible, consistent with the strength of the mount.

PLATE XVII[2].

A heavy iron bed plate bolts firmly to the sole of the embrasure, and to this plate is bolted a heavy bronze socket. The gun-pivot is the same in type as that of the naval nonrecoil mounts; a ring screwed to its base to keep it from jumping out of the socket on recoil. The upper ends of the fork, instead of being fashioned into trunnion seats, are given a rectangular shape, and form short slides for steel trunnion boxes. These boxes have arms projecting front and rear, the front

arms forming pistons for the hydraulic return and spring recoil. The recoil cylinder is a steel cylindrical box abutting against the front of the fork, the piston passing completely through it, and having belleville springs strung upon its outer end, which abut against the head of the cylinder and are held in place under initial pressure by a stout nut.

In this mount the duties of the springs and the cylinders are reversed from those generally attributed to them. The springs receive all the force of the recoil and check it. As these springs are necessarily very powerful, the return would be very violent were it not checked; the cylinder is therefore introduced, and being filled with vaseline, it checks the return and prevents vibration. The length of recoil is about 1 inch. The gun is aimed and fired from the shoulder, the shoulder piece being hinged to the left side of the mount and connected to the gun by a parallel bar.

APPENDIX 48.

STRENGTH OF IRON AND STEEL AT HIGHER TEMPERATURES. BY JAMES E. HOWARD.

An exhaustive series of experiments on the tensile strength of iron and steel at different temperatures has been carried out at the Watertown Arsenal, Massachusetts, additional experiments being in progress extending the scope of the investigation to other physical properties and to the effects of special treatment in heating and cooling.

The tensile tests embrace results obtained with cast iron, wrought iron, and steel, the latter representing metal containing carbon in amounts from 0.09 to 0.97 per cent and covering a range of temperatures from zero to 1685° F.

In presenting the results the determination of the coefficients of expansion by heat will first be referred to, followed by the description of the several features observed in tensile tests and also certain observations of a miscellaneous character incidental to the main series of tests.

COEFFICIENTS OF EXPANSION.

A direct method of determining the coefficients of expansion was adopted.

The experimental bars were first placed in a cold bath of water containing broken ice; they were measured on a gauged length of about 35 inches, defined by small drilled and countersunk holes, then transferred to a hot bath containing oil, where they were again measured, and finally returned and measured in the cold bath. The range of temperatures to which they were then exposed was about 210° F., as defined by mercurial thermometers.

While in the baths they were submerged one-half to three-quarters of an inch from the surface of the liquids, contact points of the micrometer penetrating the liquid and entering the drilled holes in the experimental bars, while the micrometer itself remained above the surface. The length of the micrometer was compared from time to time with a reference bar kept in the cold bath.

The experimental bars were exposed to the temperature of each bath a period of at least two hours before measurements were taken.

From the results it appeared that the cast iron possessed the lowest coefficient of expansion, the wrought iron and mill steel the highest, and that the coefficients of the several grades of steel followed closely in the order of their carbon content. Thirty bars having been experimented with, and in these the relative rate of expansion following closely the carbon present, other elements varying over wide limits but apparently without material influence on this property, it is therefore believed that carbon exerts a controlling influence on the rate of expansion of steels, the rate in hot-worked or annealed metal diminishing as the percentage of carbon increases.

TABLE 1.

Metal.	Chemical composition.			Coefficient of expansion per degree F. per unit of expansion.
	C.	Mn.	Si.	
Wrought iron	.....	.....	.....	0.0000067302
Steel	0.09	0.11	.....	0.0000067561
Do	0.20	0.45	.....	0.0000066259
Do	0.31	0.57	.....	0.0000065149
Do	0.37	0.70	.....	0.0000066597
Do	0.51	0.58	0.02	0.0000066202
Do	0.57	0.93	0.07	0.0000063891
Do	0.71	0.58	0.08	0.0000064716
Do	0.81	0.56	0.17	0.0000062167
Do	0.89	0.57	0.19	0.0000062335
Do	0.97	0.80	0.28	0.0000061700
Cast iron	.....	.....	.....	0.0000059261

A most remarkable result follows when the steels are hardened. In that state the higher carbon steels displayed the higher rate of expansion. Whereas before hardening a bar containing 0.89 C. showed a coefficient of expansion of 0.0000062, after hardening the coefficient actually rose to nearly 0.0000075. It was subsequently restored by annealing to the primitive value.

The rate of expansion of the lower carbons were less, if at all, affected by sudden quenching in water from a bright cherry-red heat.

In making observations on hardened bars the coefficients should be taken from the decriments in length in passing from the hot to the cold bath or else the metal should be initially exposed to the temperature of the hot bath.

When these hardened bars were exposed to the hot bath for the first time the apparent coefficient was found so low as 0.0000023 in one instance, but this resulted from a diminution in length which seemed to take place simultaneously with and in opposition to the dilatation by heating.

In each hardened bar there was a diminution in length found when they were returned to the cold bath—least for the low carbons, greater for the higher carbons.

TENSILE TESTS.

Bars tested at lower than ordinary atmospheric temperatures were surrounded with a mixture of snow and salt. At higher temperatures the specimens were heated by means of gas burners, arranged below a muffle in the testing machine. By varying the number of gas burners employed the pressure of the gas and the arrangement of diaphragms in the muffle for diffusing the heat each specimen was brought to the desired temperature and there kept during the continuance of the test.

Temperatures were estimated from the expansions of the specimens, the recorded temperatures being based on the coefficients of expansion previously determined. The determination of the actual coefficients for higher temperatures is reserved for future experiment.

THE ELASTIC LIMIT.

As defined by the proportionality limit of stress to strain the elastic limit of each grade of steel was highest at the lowest temperature experimented with, and from this maximum value there appeared, within the limits of the experiments, to follow a gradual decline in value under increasing temperatures. The exceptions to this rule were few.

Recognizing the reduction in the modulus of elasticity which occurs with increase of temperature, still the concomitant loss in elastic limit goes on at so rapid a rate that the greatest molecular displacement and recovery due to the application and release of stress, unaccompanied by permanent set, seems to be confined to the lowest temperatures in bars of the primitive condition of this metal.

The greatest molecular restoration attainable, so far as indicated by the experiments under consideration, would result from the release of stress immediately preceding the rupturing stress when the metal was heated to the zone of temperature between 400° and 600° F.

A broader field of view will open when the experiments on tempered steel now in progress at Watertown Arsenal shall have been completed.

Inasmuch as the results obtained at atmospheric temperatures depend upon the previous mechanical or thermal treatment of the metal, as well as upon its chemical composition, we should expect in the light of present experience to meet decided modifications in results of tests made in other parts of the gamut of temperatures.

Whatever maximum values of elastic limit may ultimately be attained by special treatment the evidence before us shows these steel bars, which were subjected to substantially the same treatment throughout in their manufacture, to have had their elastic limits reduced directly as the temperature was increased. The slow viscous flow under the highest temperatures tends to obscure the results, and while the tests were made with moderation, not hurriedly, yet a longer period under stress would, it is thought, have yielded lower values.

Under the dissociating influence of elevated temperature a very slight external stress partially overcomes the forces of cohesion and causes permanent distortion, and it becomes difficult to identify the period at which the metal ceases to possess a true elastic limit.

TENSILE STRENGTH.

Beginning at zero temperature the tensile strength of each of the several grades of steel was characterized by a reduction in strength until the temperature of 200° to 250° F. was reached. From this point the strength increases, reaching a maximum between 400° and 600°. This is the zone of greatest strength. The lower limit of temperatures being zero F. in these experiments, we can only call attention to the direction of the curves of strength as possibly signifying greater strength at still lower temperatures.

The lower carbons maintain nearly their maximum strength over a considerable part of the zone between 400° and 600° F., whereas the higher carbons abruptly turn and present a sharper crest in the curve of strength. A rapid decline in strength accompanies increased temperatures until the several grades of steel are found closely grouped together in the vicinity of 1,600° F., the differences in strength which were so great at atmospheric temperatures having now almost disappeared. The stress per square inch on the metal at the time of rupture followed curves similar to the curves of tensile strength.

It is remarkable that the curves of elastic limit should be unlike these other two.

The wrought-iron bars behaved in a similar manner to the steel. The strength of cast iron gradually increased from 70° F. until it reached the maximum at about 900° F., above which temperature there was a gradual reduction in strength. At temperatures above 1,400° F. numerous cracks were developed along the surfaces of the bars during the tests, thus showing a crumbling, brittle nature at this time.

TOTAL ELONGATION.

Generally speaking, the steels displayed the greatest elongation at the lower temperatures, decreasing in amount as the temperature increased. Strict reference is made in this remark to elongation distinct from the local contraction of area which marks the place of final rupture.

Measuring the elongation after fracture and including the fractured section, in the customary, but nevertheless faulty manner, the elongation under the highest temperatures appears greater due to the large contraction of area developed. It is, however, obviously erroneous and misleading to include the fractured section in comparisons of this kind. An examination of the ruptured specimens shows very little elongation in those tested at the highest temperature in parts of the specimen which were beyond the direct influence of the local contraction at rupture.

CONTRACTION OF AREA.

The contraction of area was least at low temperature, increasing in amount under the influence of high temperature, until finally certain steels drew down almost to a point. A steel bar containing 0.71 per cent carbon which contracted 25.2 per cent at 70° F., when raised to the temperature of 1,620° F. contracted 97.4 per cent. Great contraction brings about an enormous stretch of the metal in that immediate vicinity. Center punch marks near the place of rupture have been observed to elongate in diameter between 200 and 300 per cent. Notwithstanding this enormous stretch of surface metal and the apparently longer path traveled by the surface metal over the metal near the neutral axis, yet in many instances the appearance of the fracture indicated the surface metal was the last to actually rupture; that rupture began near the center of the bar. This was confirmed in a specimen of great contraction, the test of which was discontinued just before final rupture. The metal was filed away on one side, whereupon a cavity was revealed at the center of the bar. Between 400° and 600° F. the contraction was generally less than at lower or higher temperatures, and a tendency to fracture obliquely across the bar was observed.

THE MODULUS OF ELASTICITY.

Steel is very persistent at ordinary temperatures in maintaining a modulus of elasticity in the vicinity of 29,000,000 to 30,000,000 pounds per square inch. Overstraining cold, whereby the metal is given a considerable permanent set, causes a reduction in this value from which there is a recovery after the lapse of a few weeks. Other treatment, such as hardening and annealing, does not appear to influence this value, nor does the range in chemical composition of commercial steels.

A very decided reduction in the modulus of elasticity accompanies high temperatures. One specimen displayed a modulus so low as 14,000,000 pounds per square inch at 1,400° F.; at 70° F. its value was nearly 30,000,000 pounds per square inch.

The data on this subject are meager, but so well as we can now judge the modulus of elasticity seems to undergo a reduction the rate of which accelerates with increase of temperature.

ELONGATION UNDER STRESSES BETWEEN ELASTIC LIMIT AND TENSILE STRENGTH.

Peculiarities incident to the temperature of the specimen pertain to the stretch of the metal under stresses between the elastic limit and tensile strength.

Certain metals at ordinary temperatures display a jog in the tensile curve immediately after passing the elastic limit, the metal continuing to stretch for a time under diminished load. This jog in cold bars is believed to occur but once. In the zone of temperature between 200°

and 400° F., there has been observed a succession of alternate periods of relaxation and rigidity causing a number of jogs to appear in the tensile curve. Specimens employed in determining the contractile force developed while cooling displayed similar behavior. In the cold metal this tendency may be eliminated by first overstraining the metal and causing permanent sets in the compressive direction.

Jogs in the tensile curve evidently pertain to the metal when cold or moderately heated; they disappear at high temperatures. The higher modulus of elasticity and the higher elastic limit enable the cold metal to display the greatest rigidity under low stresses. When the zone of temperature of greatest tensile strength is reached, three stresses above the elastic limit cause less elongation than at either higher or lower temperatures. On a diagram the tensile curve in this zone of temperature would for the greater part fall on one side of all the other curves.

EFFECTS OF OVERSTRAINING HOT ON THE SUBSEQUENT STRENGTH WHEN RUPTURED COLD.

It has been found that overstraining the metal when in the zone of temperature between 350° and 750° F. resulted in elevating the elastic limit very materially when subsequently strained cold, and if the stress in the first instance closely approached the tensile strength at the overstraining temperature, there was also considerable gain in strength when ruptured cold.

Riveted joints in steel boiler plate have shown this same behavior.

Overstraining at higher temperatures, say above 1,000° F., has resulted in diminished strength when finally ruptured cold, but the annealing effects of heating doubtless tended to obscure the direct effects of straining; hence the real effect of overstraining at these temperatures remains problematical.

SLOW AND RAPID FRACTURES.

The rate of speed of producing rupture may, in ductile material, sensibly modify the results. Increasing the speed within such limits as are attainable with a testing machine of usual type, increases the apparent strength. When tested at ordinary temperatures the apparent gain in strength is proportionally small; at high temperatures an enormous gain results. As an illustration, a steel bar of 0.81 per cent carbon, tested slowly, of about five minutes' duration, showed a tensile strength of 33,240 pounds per square inch while at the temperature of 1,410° F. When ruptured in two seconds, at the same temperature, the strength was 63,000 pounds per square inch, as nearly as could be weighed.

On the other hand, long-continued stress at high temperatures effects a reduction of strength. Temperatures are reached where cohesive forces are enfeebled and viscosity appears as the principal source of internal resistance, and in this state it is difficult to define at what temperature the metal practically ceases to possess tensile strength.

THE COLOR OF THE RUPTURED BARS.

Temperature below 200 °F. did not sensibly change the color of the specimens; after 300° the metal was light straw colored; a deep straw color after 400°; purple-bronze colored, approaching blue, between 500° and 600°; after 700° a dark blue or blue-black. At 800° some specimens still retained a dark-blue color, but from this point the final color affords less satisfactory means of judging what temperature was reached.

That time is a function in coloring the surfaces was shown by the fractured ends of specimens presenting lower tints in the scale of colors than the cylindrical surfaces which had been exposed for a greater length of time to oxidizing influences. A smooth, glazed surface was found in specimens which had been exposed to a temperature of 1,000° to 1,200° F., and unlike the lower oxide tints, which were readily removed, this surface offered considerable resistance to the action of acids, and was in a measure exempt from corrosion in a dark atmosphere. The oxide began to assume a tangible thickness, a scale from 0.001 to 0.002 of an inch forming, as higher temperatures were reached. The red oxide appeared at about 1,500° F.

SPECIFIC GRAVITY AND INTERNAL STRAINS.

The presence of internal strains is apparently dependent upon local disturbances in the density of the metal. Strains remaining after external forces have ceased to act may be accounted for if permanent changes in density have been locally introduced, and the magnitude of the internal strains will be limited by the elastic limit of the material.

Elevating the temperature lowers the elastic limit, as we have seen, consequently internal strains are thereby relieved.

A determination of the specific gravity of the metal near the ruptured surface of tensile specimens has shown generally a diminution in density as the result of overstraining. Whatever may have been the temperature at which rupture occurred, these observations being confined to bars hot rolled in their manufacture, we should be led to infer from these determinations that internal strains may be introduced at any temperature at which the metal possesses an elastic limit.

In all the cases thus far investigated where internal strains have resulted from sudden cooling, the quenched surfaces have been left in a state of initial compression, while the interior metal has been in a state of initial tension. An example has been met in which a small detached piece of steel had its density slightly increased by quenching in oil from a cherry-red heat; quenching in water from the same temperature caused the opposite effect, a diminution in density. An increase in density at the quenched surface should there locate tensile strains, but such an increase in density has only been met in the small detached piece referred to. Ordinary hot rolled and forged bars have their sur-

faces in a state of initial compression, as do cold-rolled and cold-hammered bars.

The internal strains of compression are augmented doubtless by the effects of the lathe tool used in cutting out the rings for these determinations, and rings in a state of initial tension experience a corresponding loss. When minute particles are removed, as in grinding with a fine emery wheel, the disturbance of the remaining metal reaches nearly or quite the minimum.

Abrasion and wear of a pronounced order, as in railway rails, exhausts the toughness of the metal, which may, however, be restored by heating.

MISCELLANEOUS OBSERVATIONS.

It appears that the shearing strength of iron is increased in that zone of temperature which gives maximum tensile strength, and while none of the riveted joints in steel plate which were tested hot failed by reason of excessive compressive stress on the bearing surface of the rivets, yet very high stresses of that kind were encountered.

Riveted joints strained at a blue heat nearly to the limit of rupture, when finally ruptured cold displayed greater strength than corresponding joints tested cold throughout, confirming the behavior of the plain tensile bars.

Concerning the so-called "critical temperature" at a blue heat, special attention was given the behavior of the metal in that range of temperature. In the tensile specimens there was a tendency to fracture in an oblique shearing direction across the metal at a blue heat; otherwise the metal displayed no peculiarity indicative of brittleness in bending tests.

The middle section of long bars was heated a full red and allowed to cool in a restrained state as regards length for the purpose of observing the contractile forces developed during cooling. So far as could be judged the contractile force was dependent upon the elastic limit as a function at each successive temperature passed over. A succession of throbs or alternate periods of rigidity and relaxation were experienced before atmospheric temperatures were reached. This peculiarity was subsequently considered explained by the jogs in the resistance of the plain tension bars previously referred to in this paper. If extreme brittleness prevailed at any given temperature, a bar restrained in length while cooling might be expected to rupture when that temperature was reached instead of the further development of permanent sets which was the observed action. When steel is punched or sheared cold, the lines of scale which are disturbed on the surface come under common observation, and similar behavior characterizes tensile tests when the elastic limit has been passed. These lines of scale take curved or nearly straight courses according to circumstances, and cross each other at oblique angles without apparent interference.

The development of these lines of scale seems to prove that relief from stress may be accomplished locally along well-defined lines and not always by a distributive effect.

When the metal is punched or sheared at a blue heat or higher temperature, these lines of disturbed scale are absent.

The full significance of this difference in behavior, according to the temperatures of the metal, is conjectural at the present time. It seems, however, to point to a possible explanation of the cause of brittleness so generally reported of steel at low temperatures.

The relief of stresses in narrow lines, if done with greater facility at low temperatures, might, it would be inferred, the sooner reach that limit of intensity adequate to produce rupture. Certain it is that whatever contributes toward brittleness at low temperatures has eluded direct demonstration thus far.

Questions of this nature involve a very exhaustive discussion of the observed properties of metals, and several investigations at present in progress are expected to supply some explanatory data.

The influence of moderately high temperatures on the endurance of metals under repeated alternate stresses is under investigation. Transversely loaded shafts have been rotated under different fiber stresses and at different temperatures from atmospheric to about 700° F.

Certain of these shafts were initially heated before the commencement of the tests; others, beginning cold, were rotated at high speeds, working under high fiber stresses, and acquired the temperature at a blue heat by reason of the internal friction developed.

Some specimens at intervals were annealed at temperatures from 400° to 600° F.

In this class of tests accidental causes, such as want of homogeneity in the metal, bring about wide variations in the results; hence a large number of tests, or those of an unequivocal character, are necessary to admit of satisfactory deductions.

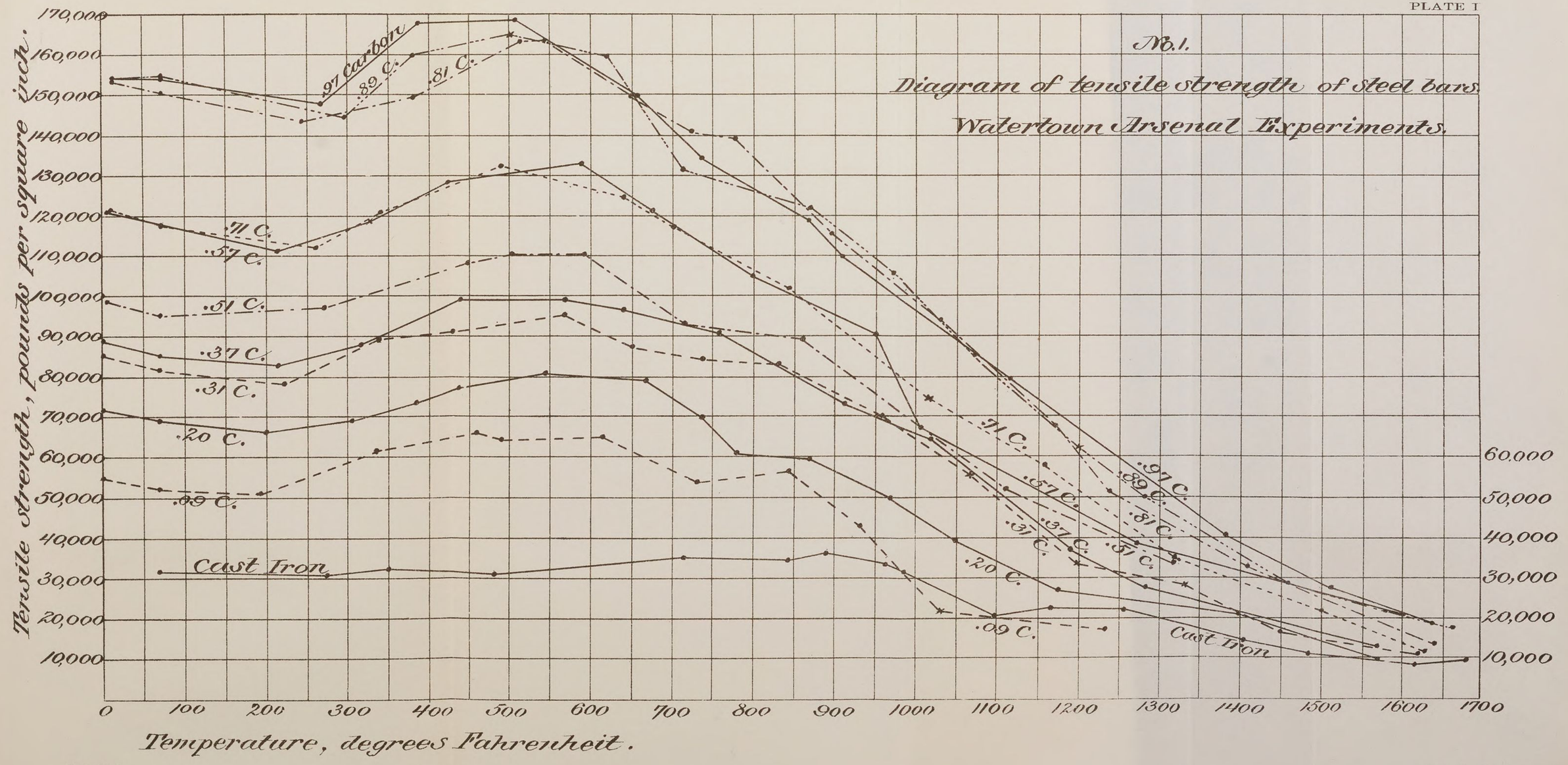
As the results now stand, we have examples in which the wrought-iron bars exhibited a most remarkable increase in endurance when tested at temperatures between 450° and 600° F. in comparison with those at atmospheric temperatures. Furthermore, annealing cold specimens at intervals at temperatures from 400° to 600° F. generally prolonged the life of the metal. With a mild grade of steel the indications were not of so pronounced an order. Bars run under high fiber stresses appeared to be benefited by the frequent annealings; at lower fiber stresses the annealed specimens were not changed, or gave a slightly lower endurance.

Steel bars tested at about 400° F. displayed increased endurance, and when tested with a stream of cold water flowing over the specimen similar results followed, comparing the results with those tested at atmospheric temperatures; which latter, it should be remarked, gener-

ally acquired a temperature of 150° F., more or less, at the close of the test.

Wrought-iron bars which ran for a time at a blue heat were suddenly cooled with water and subsequently ruptured cold appeared to have sustained no material injury by that treatment. Steels of high initial rigidity, due to cold rolling or cold drawing, have their limits of endurance under repeated alternate stresses greatly reduced by annealing at high temperatures.

Observations on the recalescence of steel have confirmed the experience of others who have observed that phenomenon.


No. 1.
Diagram of tensile strength of steel bars.
Watertown Arsenal Experiments.
Tensile strength, pounds per square inch.
Temperature, degrees Fahrenheit.
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
.97 Carbon
.89 C.
.81 C.
.71 C.
.57 C.
.51 C.
.37 C.
.31 C.
.20 C.
.09 C.
Cast Iron

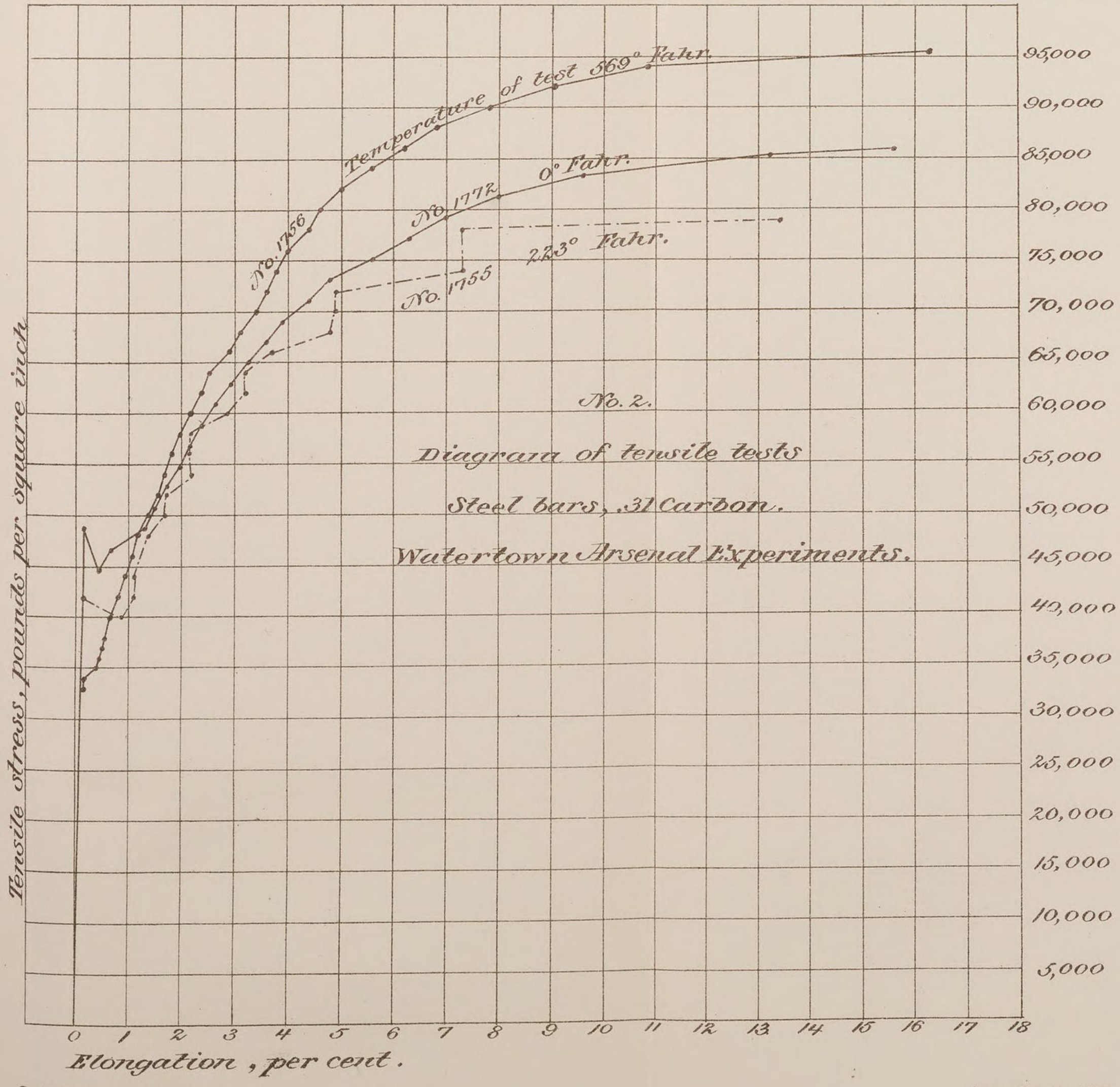
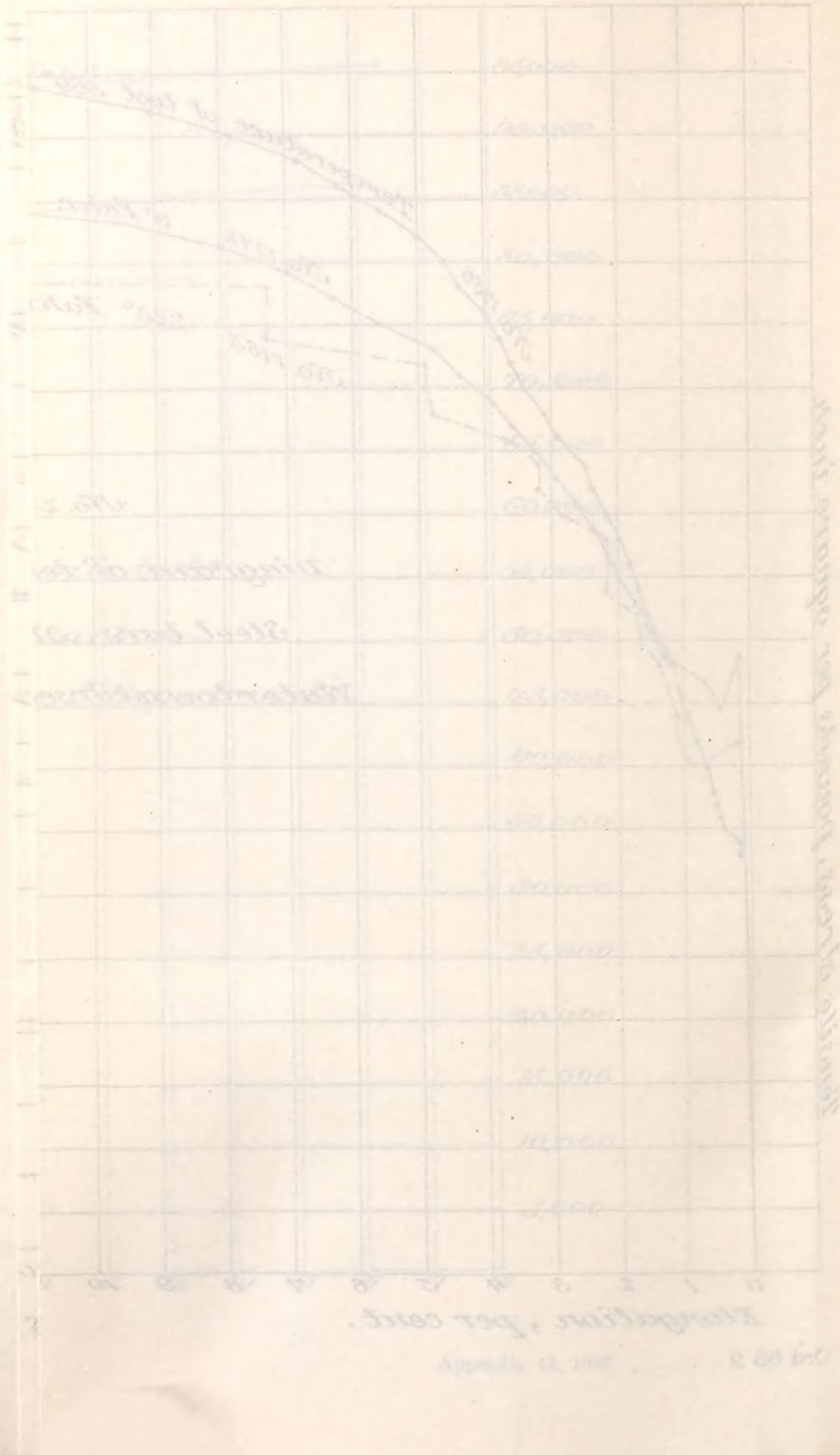

Temperature of test 569° Fahr.
No. 1756
No. 1772
0° Fahr.
223° Fahr.
No. 1755
No. 2.
Diagram of tensile tests
Steel bars, .31 Carbon.
Watertown Arsenal Experiments.
Tensile stress, pounds per square inch
95,000
90,000
85,000
80,000
75,000
70,000
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Elongation, per cent.

PLATE II.



APPENDIX 49.

RECOIL OF .45 CALIBER AND .30 CALIBER RIFLES, WITH CHARGES OF BLACK AND SMOKELESS POWDERS, WITH ACCOMPANYING DATA OF EXPERIMENTS FOR DETERMINING THE EFFECT UPON INITIAL VELOCITIES DUE TO VARIATIONS IN THE LENGTH OF BARREL, WEIGHT OF BULLET, AND WEIGHT OF POWDER CHARGE. BY LIEUT COL. J. P. FARLEY, ORDNANCE DEPARTMENT, U. S. ARMY.

(8 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., January 24, 1893.

SIR: I have the honor to state that additional tests with smokeless powders have been made at this arsenal, in compliance with the letter of instructions of the Chief of Ordnance, dated November 14, 1892.

Great stress has been laid upon the so-called anti-recoil properties of these powders, and it is with a view of finally disposing of this question that careful experiments and computations have been made.

The powders referred to are denominated rifleite and S. R. smokeless, which, it is said by their advocates, are "definitely found * * * in every way superior to any others that have been tried."

This claim presumes some inherent property in these powders not possessed by other smokeless or black powders in more common use, whereby a standard muzzle velocity and projectile energy is maintained without at the time being accompanied by the usual shock of recoil.

It has been suggested that if a "low pressure, long sustained," for any of the powders tested could be realized, as against a more sudden and less sustained pressure with powders in ordinary use, then the time in which the shoulder of the firer must absorb a given energy of recoil would be greater, the effect would be less like that of a blow, and the shock correspondingly ameliorated. Thus, although an equal muzzle velocity may be communicated to the projectile in the same gun by different powders, that powder by which the highest acceleration of velocity is produced in the projectile in its passage through the bore should give the greatest sensation of shock, since correspondingly sudden changes would be produced in the velocity of recoil of the rifle resting in contact with the shoulder of the firer.

The action of such a powder would be characterized by a relatively high pressure suddenly developed and then falling off rapidly towards the muzzle. On the other hand, the least possible sensation of shock should be produced by a powder giving pressures so regulated as to cause the projectile velocity to be uniformly accelerated from seat to muzzle.

These views are advanced in support of what might be claimed for a suitable powder in the way of ameliorating the shock of recoil against the shoulder of the firer; they are aside from the question of maximum recoil energy as usually computed, or the total work of recoil as measured by the dynamometer.

That the rifleite and S. R. powders, however, do not possess this property to any greater degree than a number of other powders that have been tried can be readily demonstrated, and at the same time the reason of the greatly reduced recoil of the .30-caliber rifle as compared with the .45 caliber can be made apparent.

To elucidate the question requires a consideration of the forward motion of the projectile (with its powder charge) from its seat in the chamber of the rifle and the simultaneous motion of the rifle, the quantity of such motion at each and every point of the path of projectile in the bore being the same for the gun on the one hand and the projectile, with its unconsumed powder charge, on the other.

This problem can only be investigated with a certain degree of approximation dependent upon the correctness of the measure of the velocity of the projectile from seat to muzzle, a measure which may be directly derived from the method of successive shortening of barrel. Sébert points out certain sources of inaccuracy in this method; it is, however, admittedly capable of producing fairly accurate results.

In entering upon a discussion of this question we will assume in the first place a powder to be denominated throughout this discussion O K, and which is capable of imparting a muzzle velocity of 1,300 foot-seconds to the 500-grain .45-caliber bullet (Pl. I); and, in a second instance, a similar O K powder capable in like manner of imparting a velocity of 2,000 foot-seconds to the 220-grain bullet .30 caliber (Pl. II). The pressure being taken as uniform throughout the barrel, that is, 4,557 pounds per square inch (Pl. I) in the first hypothesis and 10,679 pounds per square inch in the second (Pl. II); the pressures being derived as the quotient resulting from a division of the muzzle energy of the projectile by the path over which the force operates.

The velocity curves (parabola) for these O K powders, which result from the application of an assumed uniform force, are derived from the relation—

$$v : v' : : \sqrt{a} : \sqrt{a'}$$

A comparison of the curves of these assumed O K powders with those of the smokeless and black powders under consideration will, it is thought by reference to Pls. I and II, show with a fair degree of approximation the removal of the powders used in .45 and .30 caliber arms from the standard assumed—in the matter both of velocity and pressure.

The curves A and B, Pl. I,* and the curves C and D, Pl. II, have been approximately determined, as before stated, by employing various barrel lengths for the purpose, the only ready means at hand, and that for the curves, Pl. II, from data obtained in like manner.

The instrumental velocities in both cases have been reduced to muzzle velocities.

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* The data for the curves, Pls. I and II, have been derived from experiments made under my personal supervision; the former by Second Lieut. R. G. Paxton, Tenth Cavalry, now on temporary duty at this arsenal, and the latter by Lieut. J. W. Benét, Ordnance Department.

METHOD OF CONSTRUCTION OF VELOCITY AND PRESSURE CURVES.

VELOCITY CURVES.

(Table I, Pl. I.)

(1) Velocity curves for 30 grains S. R. smokeless powder and 66 grains Du Pont black powder, fired in a Springfield rifle, caliber .45, with a 500-grain bullet.

The barrel was successively cut to the lengths indicated in the left-hand column in the following table, and the instrumental velocity for each length found by taking the mean of a number of shots.

The velocities thus obtained were then reduced to the muzzle velocities recorded.

TABLE I.

1	2	3	4	5	6
		Muzzle velocities—			
Number of shots.	Length of barrel.	For 30 grains of S. R. powder.		For 66 grains of Du Pont powder.	
		Observed.	Corrected.	Observed.	Corrected.
	Inches.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
10	32.6	1,300.0	1,300	1,300.0	1,300
5	30.0	1,268.0	1,282	1,279.0	1,282
4	25.0	1,266.0	1,254	1,254.5	1,254
4	20.0	1,202.0	1,216	1,216.0	1,220
4	15.0	1,166.0	1,258	1,133.0	1,176
4	10.0	1,114.5	1,060	1,062.6	1,110
.....	5.0	825.0	825	903.0	903

NOTE.—From the ordinates of the mean velocity curves, Pl. I, S. R. and black powders, the corrected values for velocity in columns 4 and 6, Table I, have been obtained, and these velocities were employed in determining the corresponding pressures given in Table II.

From this table the data were obtained for the velocity curves of both the black and the S. R. powders when employed in the .45-caliber rifle.

The results recorded in column 3, obtained by employing 30 grains of S. R. powder in the .45-caliber rifle, for which it was not well adapted, were not entirely satisfactory. The powder had to be used in compressed charges to produce a muzzle velocity of 1,300 foot-seconds, the service projectile velocity for the arm.

TABLE II.—*Pressure curves.*

(Plate I.)

From $P = m\,v\,\frac{d\,v}{d\,x}$, $P = m'v\,\frac{d\,v}{d\,x}$, and $P' = \frac{P}{\pi\,r^2}$.

1	2	3	4	5	6	7
	S. R. smokeless powder (30 grains charge, 500 grains bullet).			Du Pont black powder (66 grains charge, 500 grains bullet).		
Length of barrel.	Corrected muzzle velocity.	Computed pressure per square inch, from $P = m\,v\,\frac{d\,v}{d\,x}$.	Computed pressure per square inch, from $P = m'\,v\,\frac{dv}{dx}$.	Corrected muzzle velocity.	Computed pressure per square inch, from $P = m\,v\,\frac{dv}{dx}$.	Computed pressure per square inch, from $P = m'\,v\,\frac{dv}{dx}$.
Inches.	*Ft. secs.*	*Pounds.*	*Pounds.*	*Ft. secs.*	*Pounds.*	*Pounds.*
32.6	1,300.0	1,338	1,378	1,300	1,338	1,426
30.0	1,282.0	1,380	1,421	1,282	1,380	1,471
25.0	1,254.0	1,450	1,493	1,254	1,467	1,564
20.0	1,216.0	1,650	1,699	1,220	1,970	2,100
15.0	1,158.0	2,100	2,163	1,176	2,890	3,081
10.0	1,060.0	4,100	4,223	1,110	4,700	5,010
5.0	825.5	10,400	10,687	903	10,300	10,979
2.275	465.0	27,000	27,810	583	25,000	26,650

In the above (Table II) P = pressure of powder gas in pounds; P' = pressure of powder gas in pounds per square inch; m, v, and x = mass, velocity, and path of bullet, respectively; m' = mass of bullet + one-half of powder charge.

To find the pressure at any point assume any value of dx and erect an ordinate (v) at its middle point, draw a tangent to the velocity curve at the point of intersection with the ordinate v; erect ordinates (v' v'') at the extremities of dx limited by the tangent: $v'' - v' = dv$. Substitute the values of m, v, dv, and dx in the mechanical formulas: $P = mv\frac{dv}{dx}$ and $P' = \frac{P}{\pi r^2}$ and from these we derive columns 3 and 6, Table II.

The above method of construction gives only fairly close approximations for barrel lengths greater than 5 inches, but below that length considerable possibilities of error are met with, checked however in a measure by the maximum pressure indicated by the pressure gauge.

The construction of the pressure curves locates the point of maximum pressure at about two calibers in advance of the base of the bullet seat for the .45-caliber rifle; but owing to the difficulty of construction for short barrel lengths this determination is only approximate. It is, however, in accordance with the views of authorities on the subject, as indicated by the following:

> The moment when the maximum pressure is produced depends on the quickness of the powder and the forcing of the bullet. With black small arms powders the maximum pressure appears to be produced when the bullet has moved one or two calibers. With smokeless powder it is produced a little farther along the bore.
>
> An increase of forcing produces exactly the same effect on the pressure as an increase of quickness in the powder, the maximum pressure being produced as much sooner as the resistances to movement are more considerable. (*Cours sur L'Organisation des Armes Portatives et de leurs Munitions.*)

Again since the powder gases in rushing from the muzzle of the reduced barrel at a high pressure continue to act on the bullet, giving a calculated muzzle velocity (from the instrumental velocity) in excess of that actually imparted to the bullet in the bore, this gives rise to an additional source of error.

(2) The following data were obtained for the velocity and pressure curves for the Springfield experimental rifle, caliber .30, using the 220-grain bullet and charges of Wetteren and rifleite smokeless powder.

TABLE III.—*Velocity curves.*

(Plate II.)

1	2	3	4	5	6
Number of shots.		Muzzle velocities for—			
		37 grains of Wetteren powder.		39 grains of rifleite powder.	
Wetteren.	Rifleite.	Length of barrel.	Derived.*	Corrected.†	Derived.*	Corrected.†
		Inches.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
20	2	32.6	2,000	2,000	2,000.0	2,000.0
20	2	31.6	1,992	1,992	1,996.5	1,966.5
20	2	30.0	1,972	1,972	1,995.0	1,985.0
20	2	28.6	1,939	1,960	1,964.0	1,970.0
10	2	22.6	1,910	1,900	1,924.0	1,910.0
10	2	17.6	1,807	1,800	1,825.0	1,820.0
10	2	12.6	1,674	1,660	1,619.0	1,630.0
10	.....	7.6	1,469	1,435	.....	1,360.0
8	3	5.6	1,240	1,245	1,215.0	1,218.0
.....	.....	2.775	.....	670	.....	750.0

* See Report A herewith, from which the muzzle velocities given in columns 3 and 5 are derived and also adjusted to correspond to the standard velocity of 2,000 foot-seconds for full length of barrel.

† See note to Table I, page 7.

TABLE IV.—*Pressure curves.*

(Plate II.)

From $P = m\,v\,\frac{dv}{dx}$, $P = m'\,v\,\frac{dv}{dx}$, and $P' = \frac{P}{\pi\ r^2}$.

1	2	3	4	5	6	7
	Wetteren powder (37 grains charge, 220 grains bullet).			Rifleite powder (39 grains charge, 220 grains bullet).		
Length of barrel.	Corrected muzzle velocity.	Computed pressure per square inch, from $P = m\,v\,\frac{dv}{dx}$.	Computed pressure per square inch, from $P = m'\,v\,\frac{dv}{dx}$.	Corrected muzzle velocity.	Computed pressure per square inch, from $P = m\,v\,\frac{dv}{dx}$.	Computed pressure per square inch, from $P = m'\,v\,\frac{dv}{dx}$.
Inches.	*Ft. secs.*	*Pounds.*	*Pounds.*	*Ft. secs.*	*Pounds.*	*Pounds.*
32.6	2,000	3,500	3,794	2,000	3,000	3,266
28.6	1,960	3,700	4,011	1,970	3,500	3,810
22.6	1,900	5,000	5,420	1,910	4,800	5,225
17.6	1,800	6,900	7,480	1,820	6,800	7,403
12.6	1,660	9,700	10,520	1,630	10,000	10,887
7.6	1,435	14,650	15,878	1,360	14,650	15,948
5.6	1,245	21,700	23,525	1,218	21,200	23,079
2.775	670	38,000	41,195	750	42,000	45,723

When the above experiments were made the amount of rifleite on hand was not sufficient to admit of an accurate determination of the velocity imparted to the bullet by that powder. Only two shots could be fired for each barrel length, and no record was made for the 7.6-inch length.

It has been found that the maximum pressure indicated for this powder by the pressure gauge is in excess of that indicated for the Wetteren charge, giving the same velocity, by from 3,000 to 5,000 pounds per square inch. Consequently a maximum pressure of 42,000 pounds was assumed at 3 calibers in advance of the bullet seat, giving a velocity at that point of 750 foot-seconds.

In this manner an additional point in the velocity curve was obtained.

From the curves, Pl. II, it is seen that with the rifleite the pressure rises more rapidly than with the Wetteren and to a greater maximum; it falls off more rapidly, afterward more slowly, and again more rapidly toward the muzzle, but it is quite possible that the rifleite curves might be considerably altered by a more extended determination of the velocities.

DYNAMOMETER RECORD.

The Frankford Arsenal recoil dynamometer consists of an arrangement of a spiral spring under an initial compression of 50 pounds, and is graduated to measure the work of recoil in foot-pounds. The graduations were verified as follows:

Length of spring without compression ..... 6·9″
Length of spring under a weight of 75 pounds ..... 4·5″
Path due to this pressure ..... 2·4″=0·2′

From Bartlett's Mechanics we have for a spiral spring: (I) $P=C\,x$.
Substituting $P=75$ and $x=0.2'$ we have $C=375$.
Under 50 pounds compression the measured path $=1.6''=0.133'$.

Substituting $a=0.133'$ in the equation (2) $Q=C\frac{a^2}{2}$

We have Q=3.318 foot-pounds=work of initial compression, since the above substitution in equation (2) is equivalent to integrating the general equation:

$$Q=\int P\,dx.$$

between the limits $x = o$ and $x = a$.

Assuming an initial compression of 50 pounds, denote by Q'' any quantity of work of recoil, and a'' the corresponding path.

From equation (2) we have:

$$a=\sqrt{2\frac{Q}{C}}$$

Substituting $a = a' + a''$ and $Q' + Q''$.

we have $$a''=\sqrt{\frac{2\,(Q'+Q'')-a'}{C}}.$$

or $$a''=\sqrt{\frac{2\,Q''+6.636-0.133.}{375}}$$

Substituting for Q'', 1, 2, 3, 4, etc., and deducing coresponding values of a'', we have the distances from the zero point to the successive foot-pounds graduations of the scale.

By this means the graduations were shown to be correct.[1]

An attempt was made to verify the graduations by means of a falling weight, but the means employed and the results obtained were unsatisfactory.

A comparative test of the recoil of Du Pont black powder and S. R. smokeless powder, using the Springfield rifle, caliber .45, and the 500-grain bullet.

[Weight of gun and spindle, 8.8 + 3.65 = 12.45 pounds.]

1	2	3	4
Velocity at 53 feet from muzzle.		Dynamometer record of recoil.	
Du Pont (66 grains).	S. R. (30 grains).	Du Pont (66 grains).	S. R. (30 grains).
Foot-seconds.	*Foot-seconds.*	*Foot-pounds.*	*Foot-pounds.*
1,272.0	1,265.0	10.6	9.0
1,281.0	1,263.0	11.5	9.5
1,285.0	1,273.5	11.2	9.5
1,273.5	.....	11.6	9.8
1,281.0	1,270.0	10.6	9.4
1,259.0		10.5	
1,260.0	Mean . 1,268.0	10.0	Mean ... 9.44
1,265.0		10.5	
1,260.5		10.0	
1,273.0		10.8	
Mean . 1,271.0		Mean . 10.73	

Compare 10.73 with 18.42 and compare 9.44 with 14.02 to derive the ratio between dynamometer records and computed recoil.

[1] Computation made by Lieut. R. H. Paxton, Tenth Cavalry, assistant, Frankford Arsenal, 1893.

A comparative test of the recoil of different smokeless powders, using the Springfield experimental rifle, caliber .30, and the 220-grain bullet.

Powder.	No. of shot.	Weight of charge.	Velocity at 53 feet from muzzle.	Dynamometer record of recoil.	Computed muzzle velocity (Ingalls).	*Computed energy of recoil (Sèbert) (maximum).
		Grains.	*Foot-seconds.*	*Foot-pounds.*	*Foot-seconds.*	*Foot-pounds.*
Wetteren	1	37	2,046	4.6		
	2	37	2,036	5.3		
	3	37	2,028	4.6		
	4	36	2,042	4.6		
	5	36	2,018	4.6		
Mean			2,034	4.74	2,078	8.18
Rifleite	1	39.5	1,992	5.2		
	2	39.5	1,998	4.8		
	3	39.5	2,000	4.6		
	4	40	2,038	4.5		
	5	40	2,028	4.9		
Mean			2,011	4.8	2,058	8.4
French, B. N. F	1	37	2,065	4.5		
	2	37	2,055	4.5		
	3	37	2,057	4.7		
	4	37	2,087	4.8		
	5	37	2,105	5.2		
Mean			2,074	4.74	2,119	8.53
Du Pont	1	30	1,661	3.1 (Hung fire)		
	2	30	1,724	3.5 (Hung fire)		
	3	33	1,837	3.9 (Hung fire)		
	4	33	1,825	3.8 (Hung fire)		
	5	33	1,820	3.7 (Hung fire)		
Mean			1,773	3.6	1,812	6.26
Leonard, N	1	33	2,002	5.2		
	2	33	2,026	4.8		
	3	33	2,060	5.1		
	4	33	2,036	5.3		
	5	33	2,085	4.8		
Mean			2,042	5.0	2,086	7.97
Leonard, J	1	31	2,105	4.9		
	2	31	2,040	5.0		
Mean			2,072	4.95	2,117	7.99

*Combined weight of rifle and dynamometer spindle, 12.45 pounds.

The recoil dynamometer with which the preceding experiments have been made is by no means an exact instrument. True values of energy of recoil are not obtained, as the piece is not allowed to recoil freely, being constantly under the restraint of the compressed spring. Doubt as to value as a comparative test arises from the fact that the spring has an initial compression of 50 pounds. If the measured recoil were the same or nearly the same in the two cases, the initial compression would have but little effect relatively, but when a difference 10.73 —9.45 is shown, the effect of the initial compression would be considerably greater in the latter case than in the former.

Sèbert's formulas for determining the velocity of free recoil are as follows:

(1) $P\,V_o = p\,v + 3{,}000\,w$. p=weight of projectile; P=weight of piece; v=initial velocity of projectile; V_o=maximum velocity of recoil.

(2) $P\,V = (p + \frac{w}{2})v$; w=weight of charge; V and v=velocity of piece and projectile at any instant of time.

Applying these formulas to the case of the .45-caliber Springfield rifle with 500-grain bullet and charges of 66 grains of black and 30 grains of smokeless powder, to compare with the preceding dynamometer record, we deduce:

Data computed by considering—	1	2	3	4
	Weight of piece only 8.8 pounds.		Weight of piece and spindle of dynamometer, 12.45 pounds.	
	Du Pont (66 grains).	S. R. (30 grains).	Du Pont (66 grains).	S. R. (30 grains).
Muzzle velocity of bullet .....foot-seconds..	1,300	1,300	1,300	1,300
Velocity of free recoil*.....do....	11.25	10.78	7.95	7.62
Energy of free recoil*.....foot-pounds..	17.40	15.99	12.30	11.30
Velocity of free recoil†.....foot-seconds..	13.76	12.01	9.73	8.49
Energy of free recoil†.....foot-pounds..	26.05	19.84	18.42	14.02

*Corresponding to muzzle velocity of bullet. †Maximum.

From the irregularities in results obtained, such as a less recoil for a greater velocity and different values of the recoil for the same velocity and charge, it would appear that the spiral spring can not be used for making exact measurements of dynamic effects.

This is rendered more noticeable when a spiral spring is submitted to the action of a falling weight. Although the compression is approximately proportional to the energy of the blow, if we allow the same weight to fall several times through the same distance the compressions produced will be slightly different.

From the comparative experiments before given we may, however, conclude that with the ·30-caliber rifle and the 220-grain bullet the recoil is practically the same for the different smokeless powders used.

GENERAL OBSERVATIONS.

I. Velocities and Recoils.

Incidental to the questions under consideration the velocities and recoils for various conditions of rifle, bullet, and powder charges are represented in Table A and the accompanying Pls. III, IV, V, VI. Pls. VII and VIII represent the cartridges and bullets used in the experiments.

The curve *EF*, Pl. III, is constructed from Table III of my report on "Maximum Initial Velocity," dated April 2, 1875, a scaling of 2½ per cent in the tabulated velocities for the 405-grain bullet being applied for the 500-grain bullet.

The curve *CD*, Pl. III, is constructed from data supplied in report herewith, marked Addenda A.

Pl. IV, curve *AB*, is constructed from Table II of my report on "Maximum Initial Velocity."

Curves *CD* and *EF* from data supplied in report herewith, marked Addenda B.

Pl. V, curve *AB*, is constructed from Table I of my report on "Maximum Initial Velocity," the velocities being scaled up in a uniform ratio to correspond to present powder records.

Curve *CD* is constructed from data obtained by experiment at this arsenal.

The trajectories (Pl. VI) of the Rubin rifle have been carefully computed and verified by the employment of screens (Report of the Chief

of Ordnance, U. S. Army, 1889, p. 110), by Lieut. J. W. Benét, Ordnance Department.

The trajectories of the .45 and .30 caliber Springfield rifle have been computed and kindly furnished the writer by Lieut. F. P. Peck, Ordnance Department, the coefficient of reduction being assumed as unity, as advised by Capt. J. M. Ingalls, First U. S. Artillery, whose formulas have been employed in the computations.

Loss of recoil due to rifling.

Let V = muzzle velocity with rifling.
Let V' = muzzle velocity without rifling.
Let R = recoil with rifling.
Let R' = recoil without rifling.
Let K = radius of gyration of bullet.
Let L = length of twist.

Springfield rifle, caliber .45, 500-grain bullet.

Let V = 1,300 foot-seconds.
Let $L = 22'' = 1.893$.
Let $K = 0.1556'' = 0.01296$ (Metcalfe).
Let R = 22.6 foot pounds.
Substituting in Benton's formula: $V' - V = 2\,\tilde{n}\,K\frac{V}{L} = 57.77 \therefore V'$ = 1,357.77 foot-seconds and $R' = 28.43$ foot-pounds. $R' - R$ = loss of recoil due to rifling = 1.83 foot-pounds.

U. S. magazine rifle, caliber .30, 220-grain bullet.

V = 2,000 foot-seconds.
$L = 10'' = 0.833'$.
$K = 0.1049'' = 0.008746'$.
R = 7 foot-pounds.
From Benton's formula:

$$V' - V = 2\,\tilde{n}\,K\frac{V}{L} = 132 \text{ foot-seconds } \therefore V' = 2{,}132 \text{ foot-seconds.}$$

R' = 8 foot-pounds, and reduction of recoil due to rifle.
$R' - R$ = 1 foot-pound.

Radius of gyration approximately calculated by Lieut. R. G. Paxton for the 220-grain bullet by assuming an ogival head, the radius of whose generating circle is 0.435'' and substituting in Ingalls' formula

$$K = \left\{\frac{I_1 + I_2}{m_1 + m_2}\right\}^{\frac{1}{2}} = \left\{\frac{R_1^{\frac{5}{1}} F(n) + R_2^{\frac{5}{2}} a}{R_1^{\frac{3}{1}} F_1(n) + R^{\frac{3}{2}}{}_2\, 2\, a}\right\}^{\frac{1}{2}}$$

In the above,
R_1 = the radius of the base of ogive=.145''.
R_2 = mean semi-diameter of body=.15176''.
a = length of body in calibers=3.182.
n = Number calibers in radius of generating circle of ogival head=1.5.
I_1 = moment of inertia of ogival head.
I_2 = moment of inertia of body.
m_1 = mass of ogival head.
m_2 = mass of body.

CONCLUSIONS.

The investigations upon the action of different powders in the bore, and upon the recoil of the .30 and .45 caliber rifles, show that in the .45-caliber rifle comparisons were made with charges of black and smokeless powders, and in the .30-caliber rifle with charges of different smokeless powders arranged to produce nearly the standard muzzle velocity for each rifle.

The curves of velocity and pressure in the bore were arrived at by firings made with successfully shortened lengths of barrel; and the recoil, with full length of barrel, was measured by a coil spring dynamometer against which the butt of the rifle rested on firing. Approximately it was found that the point of maximum pressure is about 2 calibers in advance of the base of the bullet seat in the .45-caliber rifle and about 3 calibers in the .30-caliber rifle.

The pressures rise to a higher maximum in the .30-caliber rifle, but fall off less rapidly and are better sustained to the muzzle than in the .45 caliber.

The comparison of the smokeless (30 grains S. R.) and the black (66 grains) powders in the .45-caliber rifle was rendered less satisfactory because the S. R. powder was not well adapted to the conditions of loading, used as it was in compressed charges to obtain a muzzle velocity of 1,300 foot-seconds, to approximate the service velocity of this arm; its curves of velocity and pressure showed no superiority over those derived from the charge of black powder. The respective recoils measured by the dynamometer were 10.75 foot-pounds with the black and 9.45 foot-pounds with the smokeless powder charge, the weight of bullet (500 grains) being the same in both instances. The diminished recoil with the smokeless-powder charge was, however, to be anticipated on account of its reduced weight. A difference in the same direction is shown in the computed recoils, although the latter are considerably greater than the dynamometer records, on account of the probable inaccuracy of this instrument, and also because in using the dynamometer the attached spindle practically increased the weight of the rifle in recoil from 8.08 to 12.45 pounds.

The recoil of the .30-caliber rifle measured with this dynamometer, using charges of various smokeless powders of approximately equal weight, is about 5 foot-pounds.

The different smokeless powders produced practically an equal recoil, and it appears that in whatever way a comparison may be instituted the recoil of this rifle is shown to be less than one-half that of the .45-caliber rifle. The higher muzzle velocity of the .30-caliber bullet (2,000 versus 1,300 foot-seconds) is secured without material effect upon the recoil of the rifle by a better utilization of the force of the powder than in the .45 caliber, owing to the relatively increased length of bore, the travel of shot in the two rifles being respectively about 103 and 69 calibers.

The chief cause of the lighter recoil is, however, the reduction in relative weight of powder charge and bullet. The weight of the two rifles is practically the same (8.8 pounds, nearly), whilst the aggregate weight of charge and projectile is reduced to about 257 grains in the .30-caliber rifle as against 570 grains in the .45 caliber.

The weight of powder charge has a most important influence upon recoil, not only as affecting the weight (projectile and charge) which moves forward in the bore, but also the maximum velocity of the piece in its rearward movement. Under conditions of unrestrained recoil the maximum velocity of recoil is acquired after the projectile has left

the muzzle of the rifle; the powder gas continues to act upon the bottom of the bore, up to a certain limit still increasing the velocity of recoil, and in proportion to the mass of the charge.

The ballistic advantages of smokeless powder are to be attributed to perfect combustion and the volume of gas generated at high temperature, whereby a much lighter charge than of black powder is required to produce the same muzzle velocity in a given projectile. The reduced energy of recoil with smokeless powder is not to be attributed to the more progressive action of the powder pressure in the bore, but to the lighter weight of powder charge. It may be said, however, in the case of a small arm that the sensation of shock upon the shoulder of the firer should be ameliorated in proportion as the maximum pressure is less suddenly developed and the acceleration of velocity of projectile in the bore, from seat to muzzle, becomes more nearly uniform.

In this respect, also, smokeless powders present an apparent advantage over the black rifle powder, when the conditions of loading are properly regulated.

I am indebted to Capt. Rogers Birnie and Lieut. O. M. Lissak, Ordnance Department, for valuable assistance and suggestions in the preparation of this paper.

I am, sir, very respectfully,

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

TABLE A.—*Velocities, recoils, etc., of modern rifles.*

Designation of arm.	Type.	Magazine.	Cartridges in magazine.	Number of grooves	Depth of grooves.	Diameter of bullet.	Diameter of bore between grooves.	Diameter of bore between lands.	Twist, one turn.	Excess of bullet over bore.
					Inch.	*Inch.*	*Inch.*	*Inch.*	*Inches.*	*Inch.*
Argentina (Mauser, 1891)	Repeater	Central	5	4	0.003				9.84	
Austria (Mannlicher, 1888)	do	do	5	4	.00787	.323	.33074	.315	9.84	.008
Belgium (Mauser, 1889)	do	do	5	4	.00515	.311	.3173	.301	9.84	.01
Bulgaria (Mannlicher, 1888)	do	do	5	4	.008				9.84	
Chile (Mannlicher, 1888)	do	do	5	4	.008				9.84	
Denmark (Krag-Jörgensen, 1889)	Cut-off	do	5	6	.00591	.323	.3268	.315	11.81	.008
England (Lee-Speed, 1891)	do	do	10	7	.00393	.308	.30693	.303	10.0	.005
France (Lebel, 1886)	do	Tubular	8	4	.0045	.32165	.3240	.315	9.45	.00665
France (Berthier, 1891)	Repeater	Central	4	4	.0 6				9.45	
Germany (Model 1888)	do	do	5	4	.00472	.317	.32044	.311	9.45	.006
Holland (Mannlicher, 1892)	do	do	5	4					7.87	
Italy (Carcano, 1892)	do	do	5	4	.006			.256	7.87	
Japan (Murata, 1887)	Cut-off	Tubular	8	4	.004				11.0	
Portugal (Kropatschek)	do	do	8	4	.004				11.0	
Roumania (Mannlicher, 1891)	Repeater	Central	5	4					7.87	
Russia (Mouzin, 1891)	do	do	5	4				.3	9.0	
Spain (Mauser, 1891)	Cut-off	do	5							
Switzerland (Schmidt, 1889)	do	do	12	3	.0039	.316	.2989	.295	10.6	.021
Turkey (Mauser, 1890)*	Repeater	do	5							
United States magazine rifle, model 1892	Cut-off	do	5	4	.004	.308	.303	.3	10.0	.008
United States (Springfield, experimental)			0	3	.005	.309	.305	.3	9.5	.009
United States (Springfield, single-loader)			0	3	.005	.455	.455	.45	22.0	.005

TABLE A.—*Velocities, recoils, etc., of modern rifles*—Continued.

Designation of arm.	Length of barrel.	Weight of arm.	Weight of bullet.	Weight of powder.	Weight of 100 cartridges as carried.	Kind of powder.	Muzzle velocity.	Theoretical recoil (maximum), Sèbert's formula $PV=pv+3{,}000\,w$.	Remarks.
	Inches.	*Pounds.*	*Grains.*	*Grains.*	*Pounds.*		*Ft. secs.*	*Ft. lbs.*	
Argentina (Mauser, 1891)	29.1	8.8	211	41	6.30	Smokeless	2,120	.....	From the empirical formula $K n=125$ (Cours sur l'organisation des armes portatives et de leurs munitions), the twist may be found in calibers in arms firing projectiles n calibers in length. The relation is approximate for velocities ranging between limits of 300 and 600, but is more exact for $\frac{300+600}{2}=450$ meters, which, for the ".30 caliber, $n=4.22$ (I ".265), 220-grain bullet, gives a value for $K=29.62$ or 9" .87, increasing or decreasing with the velocity. The twist for 600 m. s. (1,968 f. s.), therefore, ranges between 30 and 35 calibers=10" to 12". Taking $K n=150$, about.
Austria (Mannlicher, 1888)	30.1	10.9	235	40	7.16	Schwab-Rubin	1,968	9.32	
Belgium (Mauser, 1889)	30.7	8.78	219	43	6.41	Wetteren	1,980	11.48	
Bulgaria (Mannlicher, 1888)	30.1	10.1	235	40	7.16	Smokeless	2,060	.....	
Chile (Mannlicher, 1888)	30.1	10.1	235	40	7.16	....do	2,060	.....	
Denmark (Krag-Jörgensen, 1889)	32.9	9.5	235	76	7.00	Black	1,770	5.8	
England (Lee-Speed, 1891)	30.2	9.5	216	30(66) B	6.50	Black; cordite	2,000	9.15	
France (Lebel, 1886)	31.5	9.25	231	46	6.15	Poudre B	2,073	.....	
France (Berthier, 1891)	.....	8.5	205	33	6.30	Smokeless	2,130	.....	
Germany (model, 1888)	29.1	8.5	225	38	6.83	Nobel	2,056	12.47	
Holland (Mannlicher, 1892)	31.1	9.1	165	36	5.43	Smokeless	2,300	.....	
Italy (Carcano, 1892)	28.8	8.25	162	34	6.00	Balistite	2,329	.....	
Japan (Murata, 1887)	29.6	9.0	238	36	6.69	Smokeless	1,850	.....	
Portugal (Kropatschek)	32.3	10.2	245	70	7.70	Black	1,760	.....	
Roumania (Mannlicher, 1891)	28.6	8.7	165	36	5.43	Smokeless	2,260	.....	
Russia (Mouzin, 1891)	.....	9.5	215	33	6.12	Kazan factory	2,600	9.4	
Spain (Mauser, 1891)	.....	.....	.....	.....	.....	.....	.....	.....	
Switzerland (Schmidt, 1889)	30.7	10.31	216	30	6.53	P. C., 1889	1,935	7.98	
Turkey (Mauser, 1890)*	28.4	8.8	213	41	6.34	Smokeless	2,110	.....	
United States magazine rifle, model 1892	30.0	8.7	220	37	5.86	Wetteren and experimental.	2,000	11.13	
United States (Springfield, experimental)	.....	8.78	220	37	5.86	....do	2,000	11.0	
United States (Springfield, single-loader)	.....	8.8	500	69	5.86	....do	1,300	26.6	

* It is reported that Turkey has just adopted the Krag-Jörgensen gun of the same model as the United States arm.—S. E. B.

References: Capt. S. E. Blunt, Ordnance Department. U. S. Army, Naval Progress, 1892; Capt. W. H. James, F. R. G. S., and Les Armes a Feu Portatives des Armées Actuelles et Leurs Munitions par un Officier Supérieur, Paris, 1894.

ADDENDA A.

FRANKFORD ARSENAL,
Philadelphia, Pa., January 3, 1893.

SIR: I have the honor to submit the following report of experiments made by your direction to determine the effect upon the velocity of the bullet, of cutting off the barrel of the experimental Springfield .30-caliber rifle to various lengths.

ARM.

Experimental Springfield rifle "A" was used in these tests.

AMMUNITION.

Lot 1.—Service experimental .30-caliber cartridge loaded with 36 grains of Wetteren powder sieved between + .08 and — .06.

Lot 2.—Service experimental .30-caliber cartridge loaded with 37 grains of Wetteren powder sieved as above.

With both lots a 220-grain uncannelured nonlubricated bullet, with German-silver jacket, was used. Two cartridges, loaded with 39 grains of rifleite and the above bullet, were also fired for each length of bore.

VELOCITIES.

Velocities were determined at 53 feet from muzzle, the mean of the results obtained with two Le Boulénge chronographs being taken for each shot.

December 27, 1892.

[Barrel normal length, 3.26 inches. Thermometer: Dry bulb, 23°; wet bulb, 23°. Barometer, 29.97″.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
20	*Ft. secs.* 1,951	*Ft. secs.* 136	*Ft. secs.* 29.2

Greatest velocity, 1,998 foot-seconds; least velocity, 1,862 foot-seconds.

LOT 2.

[Charge, 37 grains.]

20	2,004	102	20.05

Greatest velocity, 2,032 foot-seconds; least velocity, 1,930 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocity.	Mean velocity.
2	*Ft. secs.* 1,917 *1,921	*Ft. secs.* 1,919

*Hang fire.

December 28, 1892.

[Thermometer: Dry bulb, 27°; wet bulb, 27°. Barometer, 30.10″. Barrel cut off 1 inch. Length, 31.6 inches.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
20	*Ft. secs.* 1,941	*Ft. secs.* 100	*Ft. secs.* 21.7

Greatest velocity, 1,970 foot-seconds; least velocity, 1,870 foot-seconds.

LOT 2.

[Charge, 37 grains.]

20	1,988	81	20.9

Greatest velocity, 2,015 foot-seconds; least velocity, 1,934 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 2,014 1,920	*Ft. secs.* 1,967

December 30, 1892.

[Thermometer: Dry bulb, 28°; wet bulb, 28°. Barometer, 30·35″. Barrel cut off 2.6 inches. Length, 30 inches.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
20	*Ft. secs.* 1,932	*Ft. secs.* 138	*Ft. secs.* 25

Greatest velocity, 1,981 foot-seconds; least velocity, 1,843 foot-seconds.

LOT 2.

[Charge, 37 grains.]

20	1,966	120	16.5

Greatest velocity, 2,007 foot-seconds; least velocity, 1,887 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 2,013 *1,920	*Ft. secs.* 1,966

*Hang fire.

Barrrel cut off 4 inches. Length, 28.6 inches.

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
20	*Ft. secs.* 1,901	*Ft. secs.* 110	*Ft. secs.* 24.5

Greatest velocity, 1,948 foot-seconds; least velocity, 1,838 foot-seconds.

LOT 2.

[Charge, 37 grains.]

20	1,948	66	20.5

Greatest velocity, 1,980 foot-seconds; least velocity, 1,914 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 1,939 1,931	*Ft. secs.* 1,935

December 31, 1892.

[Thermometer: Dry bulb, 32°; wet bulb, 31°. Barometer, 30.20″. Barrel cut off 10 inches. Length 22.6 inches.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
10	*Ft. secs.* 1,872	*Ft. secs.* 87	*Ft. secs.* 24

Greatest velocity, 1,908 foot-seconds; least velocity, 1,821 foot-seconds.

LOT 2.

[Charge, 37 grains.]

10	1,881	90	26.3

Greatest velocity, 1,924 foot-seconds; least velocity, 1,834 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 1,946 1,863	*Ft. secs.* 1,906

[Barrel cut off 15 inches. Length, 17.6 inches.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
10	*Ft. secs.* 1,771	*Ft. secs.* 94	*Ft. secs.* 19.2

Greatest velocity, 1,827 foot-seconds; least velocity, 1,733 foot-seconds.

LOT 2.

[Charge, 37 grains.]

10	1,807	84	24.1

Greatest velocity, 1,855 foot-seconds; least velocity, 1,771 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 1,807 1,790	*Ft. secs.* 1,798

[Barrel cut off 20 inches. Length, 12.6 inches.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity.	Extreme variation.	Mean variation.
10	*Ft. secs.* 1,641	*Ft. secs.* 103	*Ft. secs.* 32.9

Greatest velocity, 1,688 foot-seconds; least velocity, 1,585 foot-seconds.

LOT 2.

[Charge, 37 grains.]

10	1,676	116	27.1

Greatest velocity, 1,721 foot-seconds; least velocity, 1,605 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities.	Mean velocity.
2	*Ft. secs.* 1,632 1,556	*Ft. secs.* 1,594

January 3, 1893.

[Thermometer: Dry bulb, 32°; wet bulb, 30°. Barometer, 29.75″. Barrel cut off 25 inches. Length of barrel, 7.6″.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity at 28 feet from muzzle.	Extreme variation.	Mean variation.
5	*Ft. secs.* 1,411	*Ft. secs.* 103	*Ft. secs.* 34.4

Greatest velocity, 1,460 foot-seconds; least velocity, 1,357 foot-seconds.

LOT 2.

[Charge, 37 grains.]

10	1,439	176	37.2

Greatest velocity, 1,511 foot-seconds; least velocity, 1,335 foot-seconds.

With 100 feet between targets it was found impossible to hit the second target. Bullets which struck the sides of the gallery and were recovered were found to have struck side on. The distance between targets was reduced to 50 feet and occasional misses occurred even at this distance. No rifleite cartridges were fired for this length of barrel, as only three were left.

[Barrel cut off 27 inches; length of barrel, 5.6″.]

LOT 1.

[Charge, 36 grains.]

Number of shots fired.	Mean velocity at 28 feet from muzzle.	Extreme variation.	Mean variation.
5	*Ft. secs.* 1,218	*Ft. secs.* 77	*Ft. secs.* 23

Greatest velocity, 1,262 foot-seconds; least velocity, 1,185 foot-seconds.

LOT 2.

[Charge, 37 grains.]

8	1,239	81	24.8

Greatest velocity, 1,270 foot-seconds; least velocity, 1,189 foot-seconds.

[Charge, 39 grains rifleite.]

Number of shots fired.	Velocities at 28 feet from muzzle.	Mean velocity.
3	*Ft. secs.* 1,216 1,259 1,255	*Ft. secs.* 1,243

The following record of pressures obtained at different times with some of the charges used in the preceding experiments is herewith submitted. These pressures were taken in a .30-caliber pressure barrel, using a crusher gauge. The copper pressure cylinders were given a suitable initial compression.

Rifleite powder, 230-grain bullet used.

Number of shots.	Charge.	Mean pressure per square inch.	Mean velocity, 53 feet from muzzle.	Date.
	Grains.	*Pounds.*	*Ft. secs.*	1892.
7	37	(*)	1,778	Nov. 15
10	39	44,500	1,920	Nov. 16
12	39½	48,100	1,990	Nov. 16

* Below 38,000.

The Wetteren powder fired at the same time gave the following results:

Number of shots.	Charge.	Mean pressure per square inch.	Mean velocity, 53 feet from muzzle.	Date.
	Grains.	*Pounds.*	*Ft. secs.*	1892.
10	36	38,000	1,876	Nov. 15
10	37	42,500	1,993	Nov. 17

Respectfully,

J. W. BENÉT,
First Lieutenant, Ord. Dept., U. S. Army,
In charge Ballistic Division.

COMMANDING OFFICER FRANKFORD ARSENAL.

ADDENDA B.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 13, 1892.

SIR: I have the honor to submit the following report of experiments conducted under experimental programmes 1 and 2.

EXPERIMENTAL PROGRAMME NO. 1.

Subject.—Experimental .30-caliber cartridge, 36 grains Wetteren (smokeless) powder, 230-grain bullet.

Object.—To determine the initial velocities due to variation in weight of bullet and variation in powder charge.

Arm.—Experimental Springfield rifle, caliber .30.

Ammunition.—.30-caliber experimental cartridge, using different charges of powder and different weights of bullet.

Conditions.—10, 20, 25, 28, 30, 34, 36, and 38 grain charges to be used with 230-grain bullet; 125, 150, 175, 200, 215, 230, 245, 260 grain bullets to be used with powder charge of 36 grains.

Firing.—Five rounds to be fired with each of the above variations in charge and projectile.

The length of the cartridge was kept the same in all of these experiments.

First. Two hundred and thirty-grain bullet with varying charges, ten grains; charge not great enough to expel bullet; bullet found in bore, 8 inches from muzzle.

20 GRAINS.

[Velocity at 53 feet from muzzle.]

Instrument No. 1.	Instrument No. 2.
Ft. secs.	*Ft. secs.*
Lost.	1,014
1,047	1,046
1,005	1,005
1,058	1,059
1,057	1,054
Mean 1,036	1,035

Mean velocity, 1,035.5 foot-seconds; extreme variation, 54 foot-seconds; mean variation, 21.3 foot-seconds.

25 GRAINS.

1,333	1,334
1,302	1,304
1,303	1,301
1,335	1,338
1,355	1,355
Mean 1,325.6	1,326

Mean velocity, 1,326 foot-seconds; extreme variation, 53 foot-seconds; mean variation, 18.8 foot-seconds.

26 GRAINS.

1,451	1,449
1,452	1,456
1,454	1,456
1,420	1,421
1,417	1,419
Mean 1,439	1,440

Mean velocity, 1,439.5 foot-seconds; extreme variation, 37 foot-seconds; mean variation, 14.2 foot-seconds.

28 GRAINS.

1,512	1,514
1,543	1,546
1,525	1,527
Lost.	1,512
Lost.	1,553
Mean 1,529	1,530

Mean velocity, 1,529.5 foot-seconds; extreme variation, 41 foot-seconds; mean variation, 15.2 foot-seconds.

30 GRAINS.

1,653	1,654
1,678	1,678
1,644	1,646
Lost.	1,676
1,699	1,700

Mean velocity, 1,670 foot-seconds; extreme variation, 46-foot seconds; mean variation, 16.8 foot-seconds.

32 GRAINS.

1,738	1,741
1,773	1,772
1,737	1,741
1,780	1,783
1,801	1,803
Mean 1,765	1,768

Mean velocity, 1,766.5 foot-seconds; extreme variation, 62 foot-seconds; mean variation, 21.8 foot-seconds.

34 GRAINS.

1,878	1,883
1,890	1,887
Lost.	1,870
1,896	1,894
1,908	1,905
Mean 1,887	1,888

Mean velocity, 1,887.5 foot-seconds; extreme variation, 35 foot-seconds; mean variation, 9.4 foot-seconds.

36 GRAINS.

1,968	1,964
1,996	2,000
2,006	2,008
2,006	2,002
2,000	1,996
Mean 1,995	1,994

Mean velocity, 1,994.5 foot-seconds; extreme variation, 44 foot-seconds; mean variation, 12 foot-seconds.

38 GRAINS.

[Velocity at 50 feet from muzzle.]

Instrument No. 1.	Instrument No. 2.
Ft. secs.	*Ft. secs.*
2,107	2,103
2,090	2,087
2,093	2,090
2,110	2,110
2,102	2,107
Mean 2,100	2,099

Mean velocity, 2,099.5 foot-seconds; extreme variation, 23 foot-seconds; mean variation, 8.6 foot-seconds.

Second. 36-grain charges with varying weights of bullet.

260-GRAIN BULLET.

Instrument No. 1.	Instrument No. 2.
Ft. secs.	*Ft. secs.*
1,900	1,896
1,896	1,900
1,900	1,905
1,910	1,910
1,942	1,942
Mean 1,909	1,911

Mean velocity, 1,910 foot-seconds; extreme variation, 42 foot-seconds; mean variation, 12.1 foot-seconds.

245-GRAIN BULLET.

1,901	1,900
1,879	1,881
1,852	1,850
1,938	1,934
1,950	1,954
Mean 1,904	1,904

Mean velocity, 1,904 foot-seconds; extreme variation, 98 foot-seconds; mean variation, 32.2 foot-seconds.

230-GRAIN BULLET.

1,946	1,942
1,981	1,978
1,942	1,938
1,978	1,978
2,020	2,022
Mean 1,973	1,970

Mean velocity, 1,971 foot-seconds; extreme variation, 84 foot-seconds; mean variation, 25.4 foot-seconds.

215-GRAIN BULLET.

1,981	1,974
1,938	1,938
1,956	1,954
1,986	1,994
1,970	1,976
Mean 1,966	1,967

Mean velocity, 1,967 foot-seconds; extreme variation, 48 foot-seconds; mean variation, 17 foot-seconds.

200-GRAIN BULLET.

1,994	1,994
1,972	1,978
Lost.	1,964
2,030	2,030
2,055	2,056
Mean 2,003	2,004

Mean velocity, 2,003 foot-seconds; extreme variation, 83 foot-seconds; mean variation, 29.6 foot-seconds.

175-GRAIN BULLET.

2,075	2,070
2,102	2,108
2,086	2,087
2,110	2,110
2,085	2,085
Mean 2,091.6	2,092

Mean velocity, 2,092 foot-seconds; extreme variation, 40 foot-seconds; mean variation, 13.6 foot-seconds.

150-GRAIN BULLET.

2,070	2,070
2,098	2,100
2,120	2,123
2,123	2,123
2,088	2,085
Mean 2,100	2,100

Mean velocity, 2,100 foot-seconds; extreme variation, 53 foot-seconds; mean variation, 18.2 foot-seconds.

125-GRAIN BULLET.

2,158	2,156
2,205	2,208
2,217	2,220
2,235	2,240
2,230	2,228
Mean 2,209	2,210

Mean velocity, 2,209 foot-seconds; extreme variation, 48 foot-seconds; mean variation, 22.8 foot-seconds.

The bullets were reduced in weight by cutting off the rear portion, thus reducing the length and bringing the bullet to the proper weight.

The anomalous results for the 245 and 215 grain weight of bullet recorded are due partly to the variations in velocity obtained with the same bullet and charge when smokeless powder is used, and to the variation in density of loading.

EXPERIMENTAL PROGRAMME NO. 2.

Subject.—Service 500-grain bullet.

Object.—To determine initial velocities due to variation in powder charge.

Arm.—Springfield rifle, caliber .45.

Ammunition.—Service rifle ball cartridge, 500-grain bullet. Different charges of powder.

Conditions.—20, 40, 60, 70, 80, 100 grain charges to be used.

Firing.—One round to be fired with each of the above charges. Velocities taken with the chronograph.

[Velocities at 53 feet from muzzle.]

Charge.	No. 1 instrument.	No. 2 instrument.	Mean.
Grains.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
20	623	623	623
40	920	919	919
60	1,163	1,162	1,162
70	1,287	1,285	1,186
80	1,370	1,367	1,368
100	1,459	1,457	1,458

Curves illustrating the above experiments are herewith submitted.

Respectfully,

J. W. BENÉT,
First Lieutenant, Ord. Dept., U. S. Army,
In charge Ballistic Division.

COMMANDING OFFICER FRANKFORD ARSENAL.

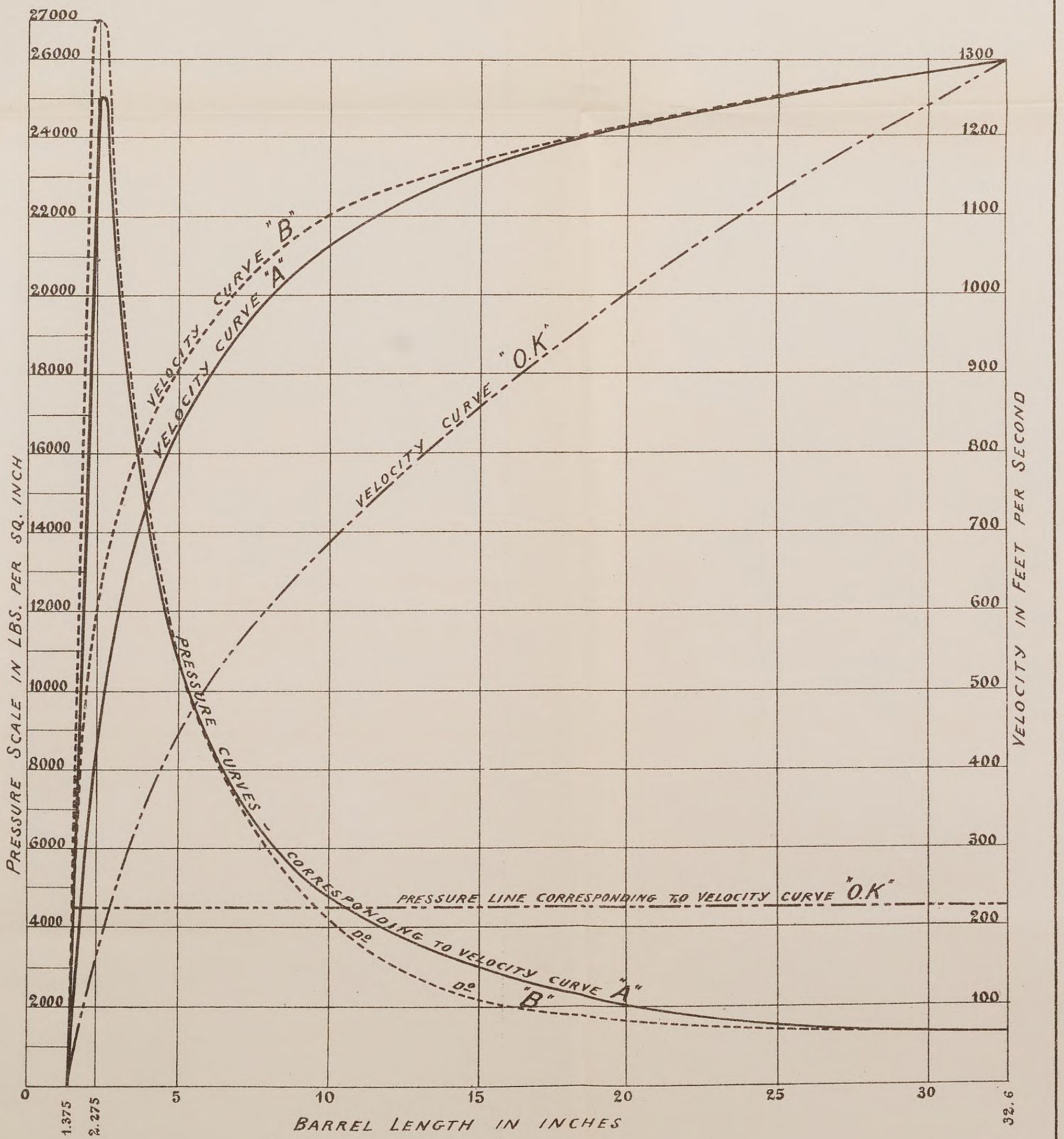
SPRINGFIELD RIFLE CAL. 45

MUZZLE ENERGY 1886.1 FT. LBS.

VELOCITY CURVE "A" – DUPONT BLACK POWDER – CHARGE 66 GRAINS – 500 GR. BULLET

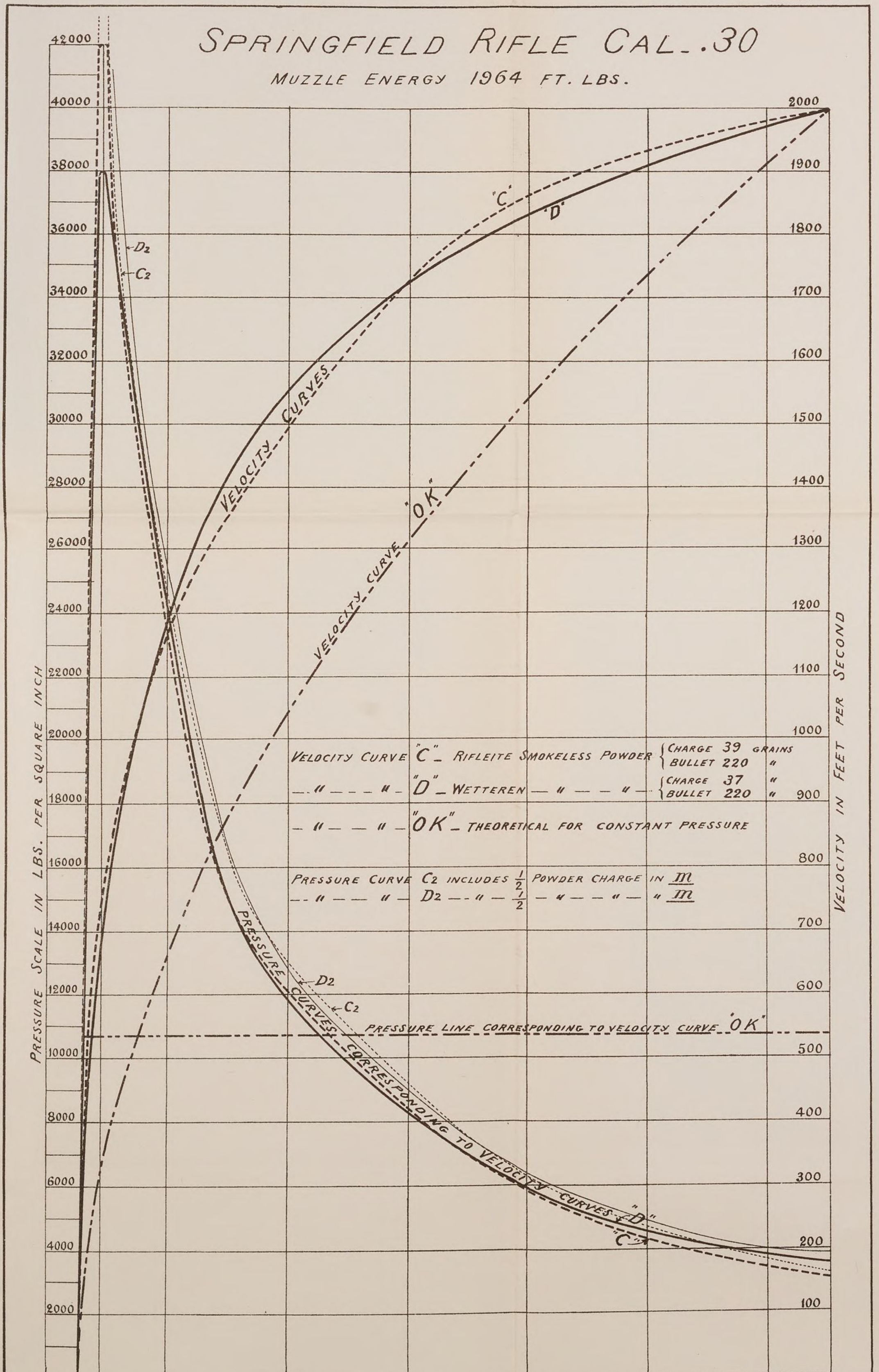
---" ----" -- "B" – S.R. SMOKELESS --- " -- – --" -- 30 -- " -- 500 – " -- " –

--- " ---- " – "O.K" – THEORETICAL FOR CONSTANT PRESSURE



SPRINGFIELD RIFLE CAL. .30

MUZZLE ENERGY 1964 FT. LBS.



INSTRUMENTAL VELOCITIES AT 53'
DUE TO VARIATION IN LENGTH OF BARREL

CURVE "AB" – VELOCITY 36 GRAINS OF WETTEREN POWDER – 45 CAL. RIFLE AND CARBINE
CURVE "CD" – VELOCITY WITH .30 CAL. RIFLE FOR RIFLE AND CARBINE LENGTH OF BORE

The law which governs the ratio of velocities and length of bore corresponding thereto, for the .45 cal. Rifle, may be summarized as follows: (CURVE "EF")

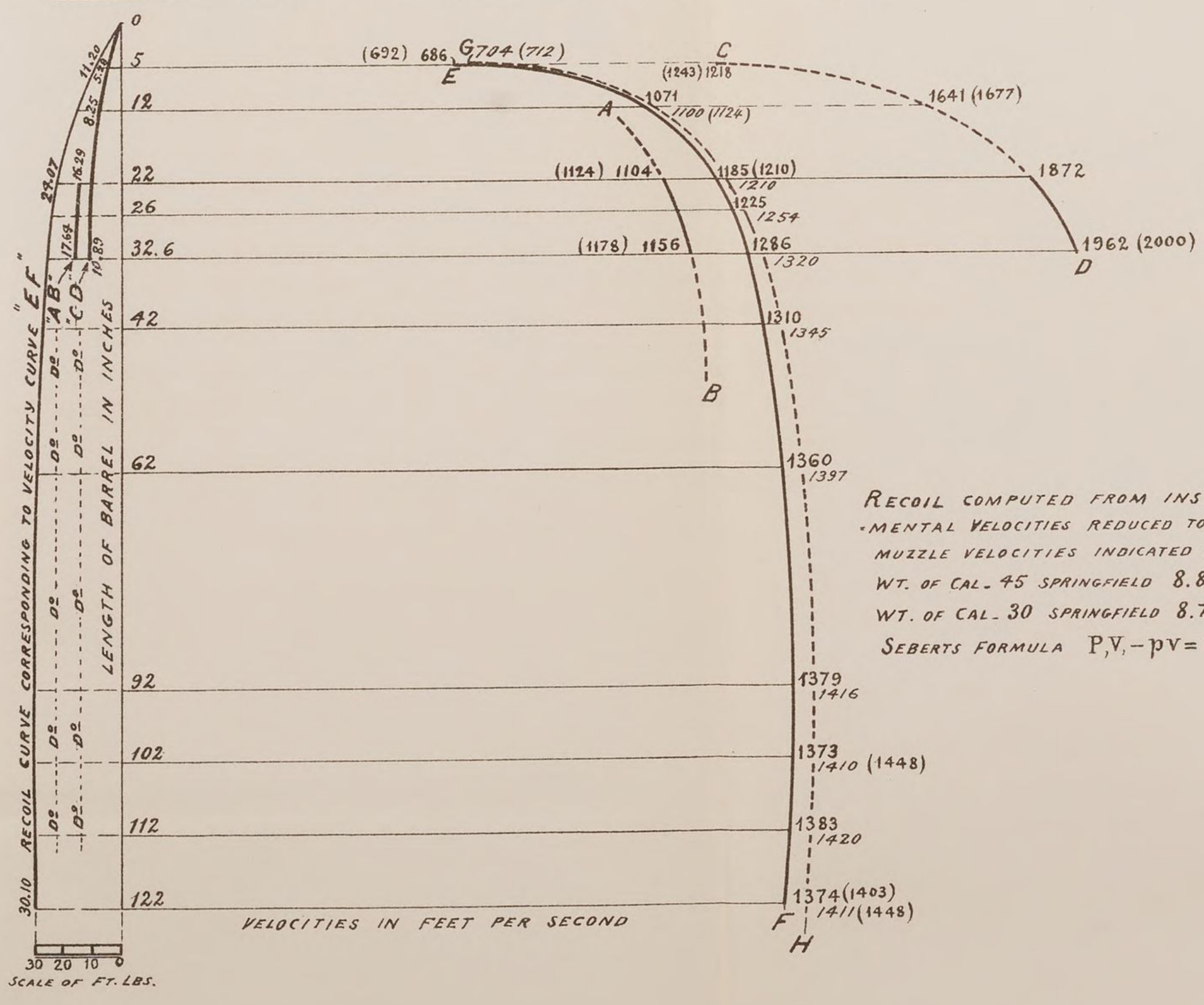
Below 50 calibers length of barrel, the initial velocities decrease rapidly in a somewhat direct ratio with the decrease in length of bore, giving 1185 f.s. for the 22 inch carbine length and 704 f.s. for the 5 in. length.

Between 22 inches (carbine length) and 32.6 inches length (rifle), the velocities increase in a ratio of about 9 f.s. to the inch and beyond 32.6 ins. and up to 92 inches length the increase is not greater than 1½ f.s. to the inch, whilst beyond that length at which the velocity is 1379 f.s. the velocity has no practical increase and falls off at 122 inches length of barrel to 1374 f.s.

The variation in velocities due to varying the length of the .30 cal. rifle barrel, is expressed by the curve "CD",

5".6 length of barrel giving	1218 f.s.	22".6 length of barrel giving	1872 f.s.
7".6 " " "	1411 "	28".6 " " "	1901 "
12".6 " " "	1641 "	30".6 " " "	1932 "
17".6 " " "	1771 "	31".6 " " "	1941 "
		32".6 " " "	1962 "

CURVE "EF" – VELOCITY WITH .45 CAL. RIFLE – 500 GRAINS BULLET
CURVE "GH" – VELOCITY WITH .45 CAL. RIFLE – 405 GRAINS BULLET



RECOIL COMPUTED FROM INSTRUMENTAL VELOCITIES REDUCED TO MUZZLE VELOCITIES INDICATED (—)
WT. OF CAL. 45 SPRINGFIELD 8.8 LBS.
WT. OF CAL. 30 SPRINGFIELD 8.79 "
SEBERTS FORMULA $P_1V_1 - pv = 3000w$

INSTRUMENTAL VELOCITIES AT 53'
DUE TO VARIATION IN POWDER CHARGE

CURVE "AB" FOR SERVICE RIFLE CAL. .45 — WEIGHT OF BALL 405 GRAINS
— " — "CD" — " — " — " — " — " — " — " — " — 500 — " —
— " — "EF" — " — EXPERIM^{L} — " — " — .30 — — " — " — " — 230 — " —

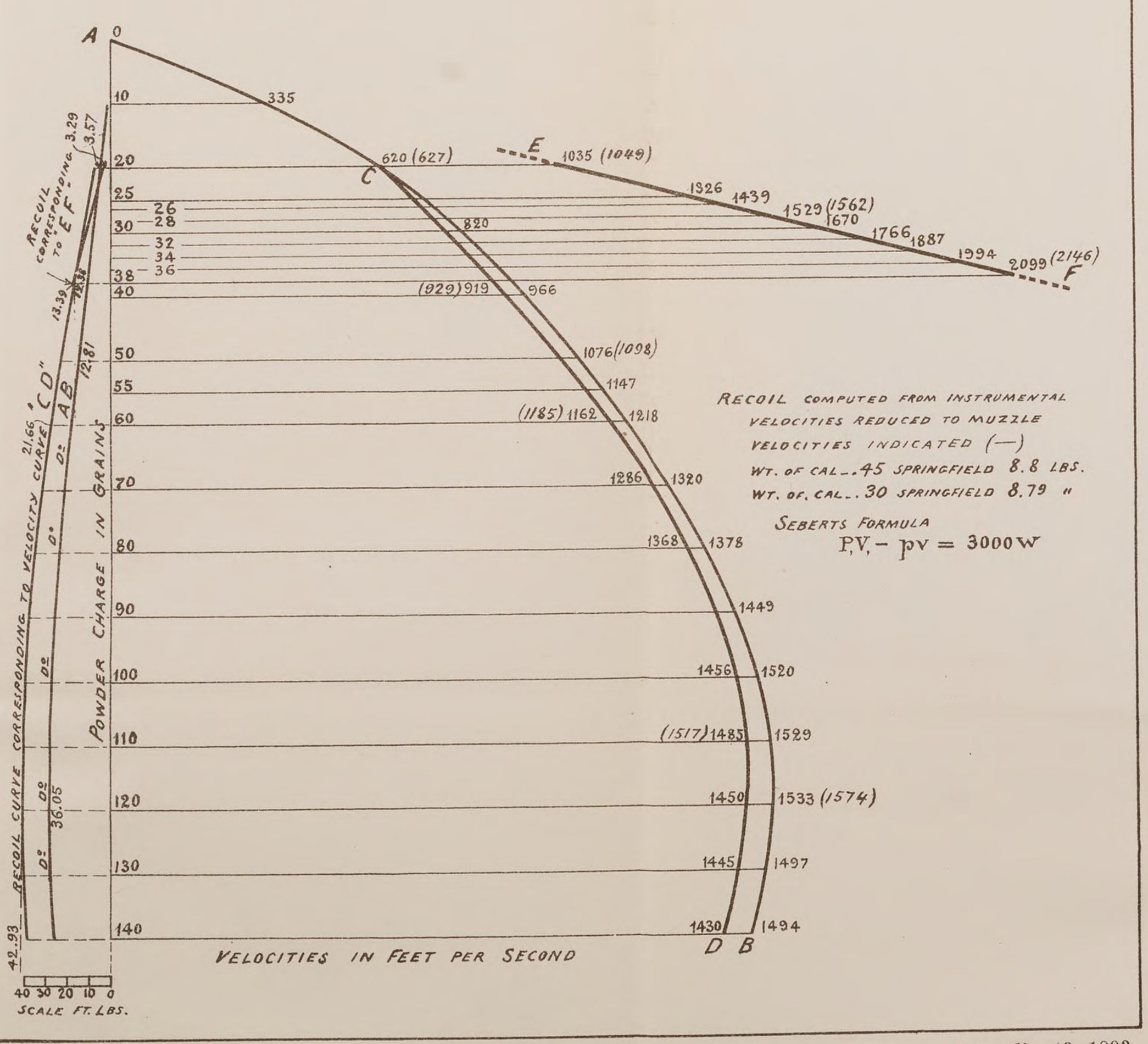
The initial velocity of the 500 grain .45 cal. bullet is 1280 to 1300 f.s. and for the .30 cal. 1990 to 2000 f.s. — 20 grains of black powder with the 500 gr. .45 cal. bullet imparts a velocity of 620 f.s. — 40 gr. 919 f.s. — 60 gr. 1162 f.s. — 80 gr. 1368 f.s. — 100 gr. 1456 f.s — 120 gr. 1450 f.s. — Charges in excess of 120 gr. rather retard than increase the velocity.

20 grains of smokeless powder in the .30 cal. rifle imparts a velocity of 1035 f.s.. 25 gr. 1326 f.s. — 26 gr. 1439 f.s. — 28 gr. 1529 f.s. — 30 gr. 1670 f.s. — 32 gr. 1766 f.s. — 34 gr. 1887 f.s. — 36 gr. 1994 f.s. — 38 gr. 2099 f.s.

The law of increase in the two cases may be summed up as follows: For the .45 cal. rifle the increase in initial velocity with increase in charge of powder between limits of 20 and 40 gr. is in ratio of 17 feet to the grain, passing the 70 gr. charge or service limit, the increase is in ratio of 5 ft. to the gr. until reaching a maximum of 1485 f.s. — for 110 gr. charge, the velocity then decreases as the powder charge increases in a ratio of 1.5 ft. to the grain.

With the .30 cal. rifle the velocity increases in a direct ratio of 53 ft. to the gr. between limits of 20 and 38 gr. and continues to increase in the same ratio to the limit of safe pressure*

* Note — *This is evolved from the mean of many observations — Single velocities for the same charge of smokeless powder frequently differ as much as 80 f.s. or 4 per ct., from which it will be seen that no very definite laws can as yet be determined, where smokeless powders are employed.*



INSTRUMENTAL VELOCITIES AT 53'
DUE TO VARIATION IN WEIGHT OF BULLET

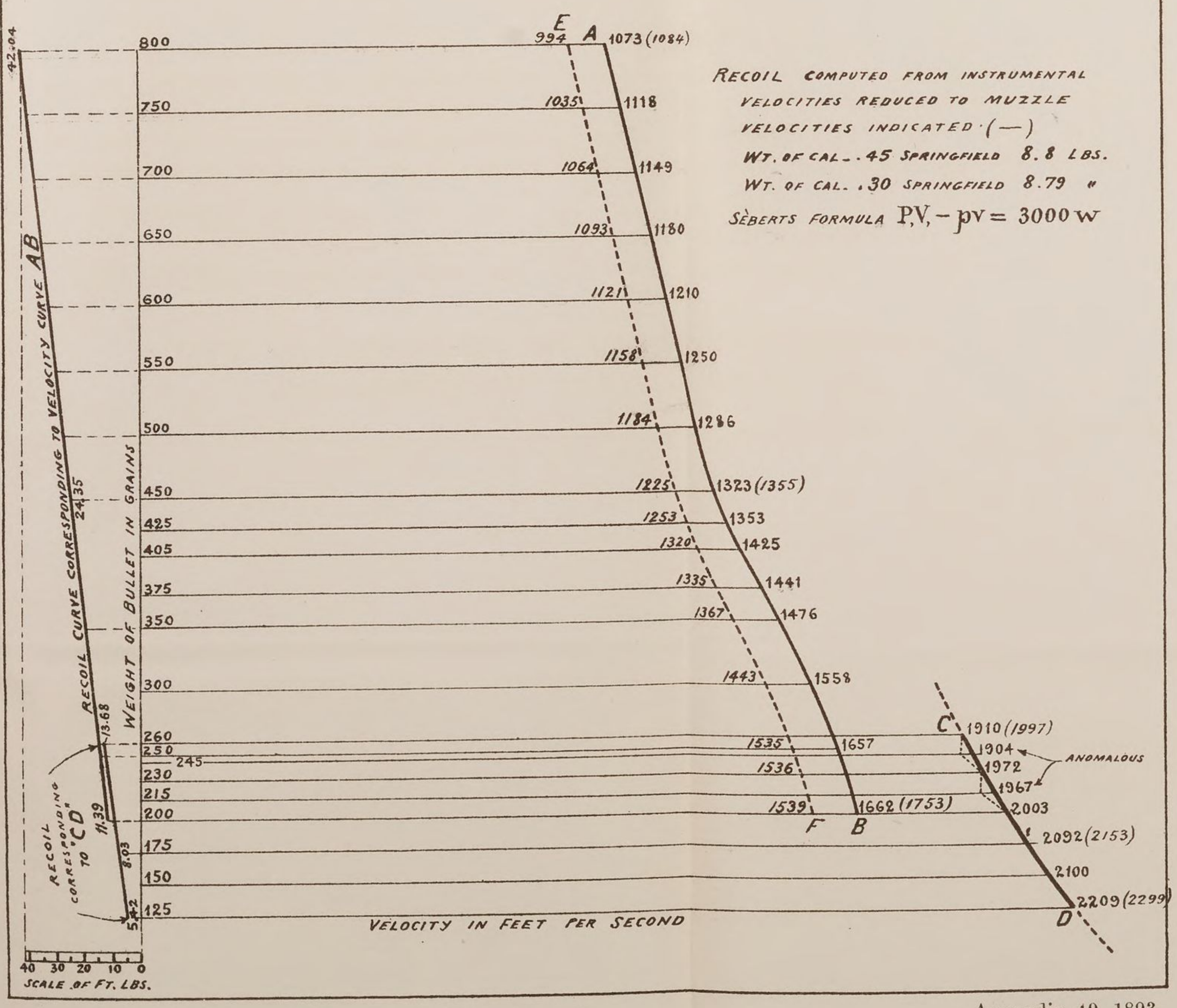
CURVE "AB" FOR SERVICE RIFLE CAL. .45 SCALED UP FOR POWDERS 1893 (Approximate).
" "CD" " EXPERTS " " " .30 CHARGE 36 GR. WETTEREN POWDER
" "EF" " SERVICE " " " .45 POWDERS 1875

Variation in weight of bullet between limits of 200 and 800 grains for the .45 cal. decreases the velocity as the weight of bullet increases in the ratio of one foot to the grain the limits being 1662 ft. on the one hand for the 200 gr. bullet and 1073 feet on the other for the 800 gr. bullet. The ratio is expressed as follows:

200 GRAIN BULLET,	1662 F.S.	450 GRAIN BULLET,	1324 F.S.
230 " "	1658 "	500 " "	1286 "
250 " "	1657 "	550 " "	1250 "
300 " "	1558 "	600 " "	1210 "
350 " "	1476 "	650 " "	1180 "
375 " "	1441 "	700 " "	1149 "
405 " "	1425 "	750 " "	1118 "
425 " "	1353 "	800 " "	1073 "

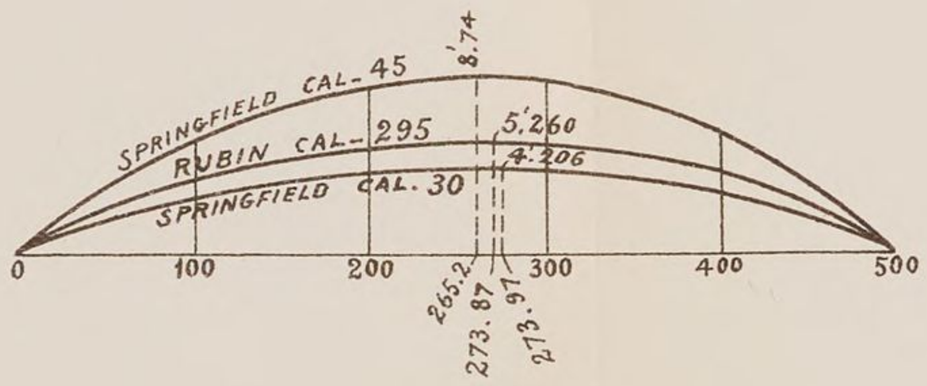
Variation in weight of bullet between limits of 125 and 260 grains for the .30 cal. decreases the velocity as the weight of bullet increases in the ratio of 2.21 feet to the grain, the limits being 2209 f.s. on the one hand for the 125 grain bullet and 1910 f.s. on the other for the 260 gr. bullet. The ratio is expressed as follows:

125 GRAIN BULLET,	2209 f.s.	215 GRAIN BULLET,	1967 f.s.
150 " "	2100 "	230 " "	1952 "
175 " "	2092 "	245 " "	1904 "
200 " "	2003 "	260 " "	1910 "



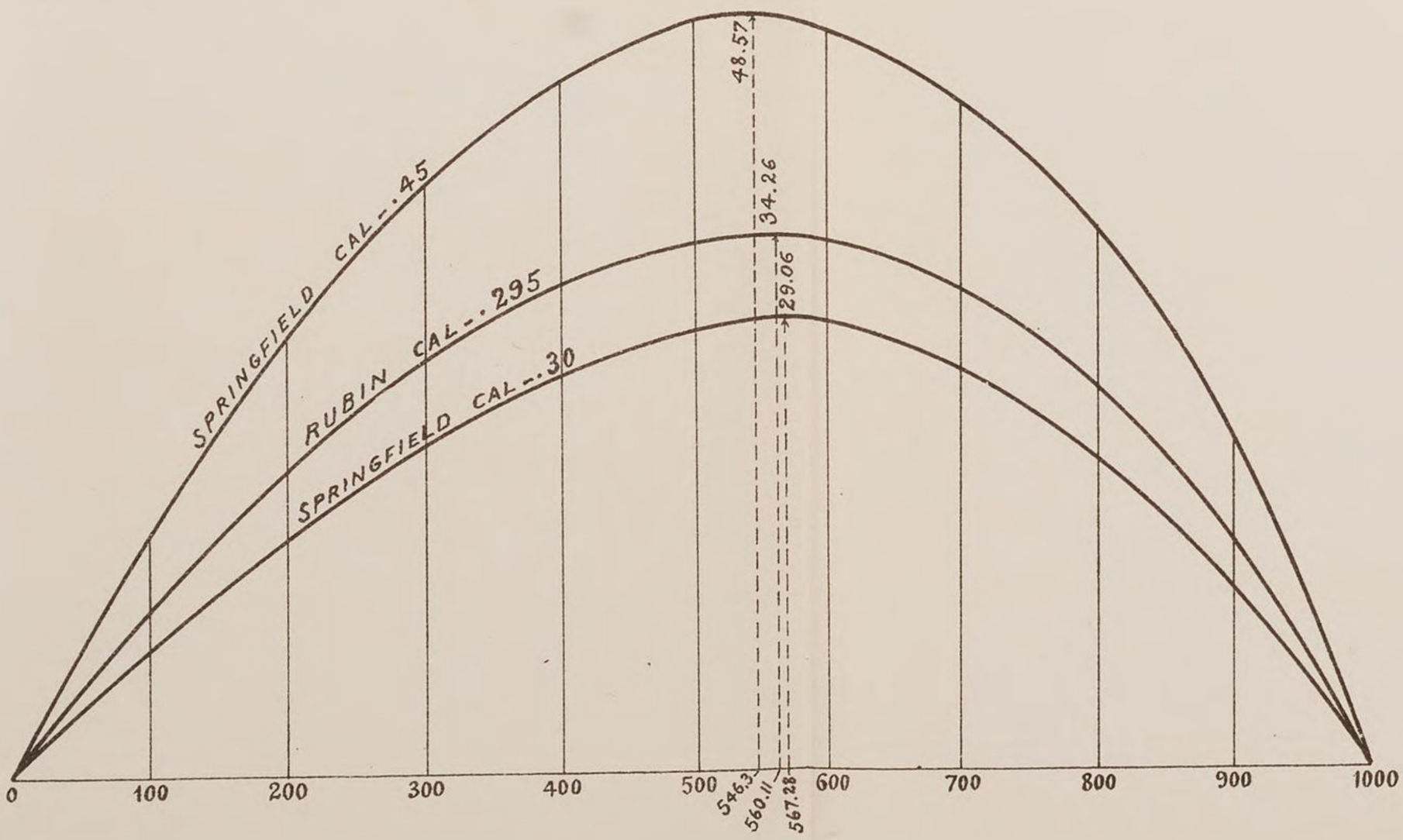
500 YARDS TRAJECTORIES

Gun	Wt. of Ball GRAINS	I.V. F. S.	R.V F. S.	Elevation
SPRINGFIELD CAL-.45	500	1301	873.54	1°-9'-39"
RUBIN » .295	217	1800	1033	39'-41"
SPRINGFIELD » .30	230	2000	1128.1	31'-49"
SPRINGFIELD » .30	220	2000	1103	34'-09"



1000 YARDS TRAJECTORIES

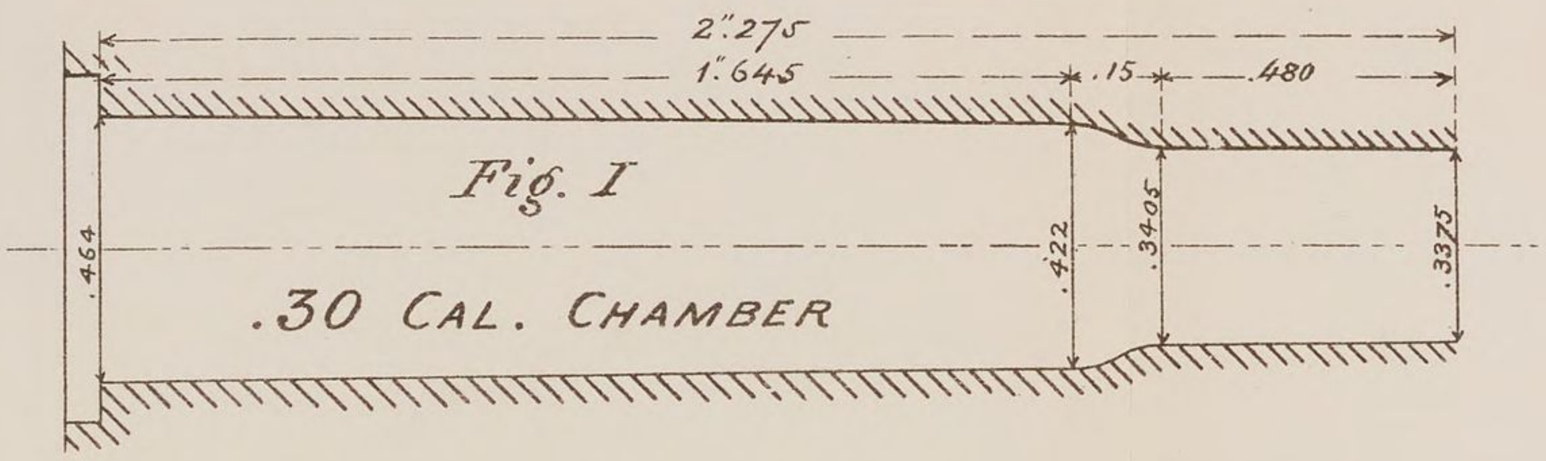
Gun	Wt. of Ball GRAINS	I.V. F. S.	R.V F. S.	Elevation
SPRINGFIELD CAL-.45	500	1301	676.17	2° 59' 53"
RUBIN » .295	217	1800	778	1° 57' 01"
SPRINGFIELD » .30	230	2000	823.16	1° 37' 7"
SPRINGFIELD » .30	220	2000	804	1° 40' 42"

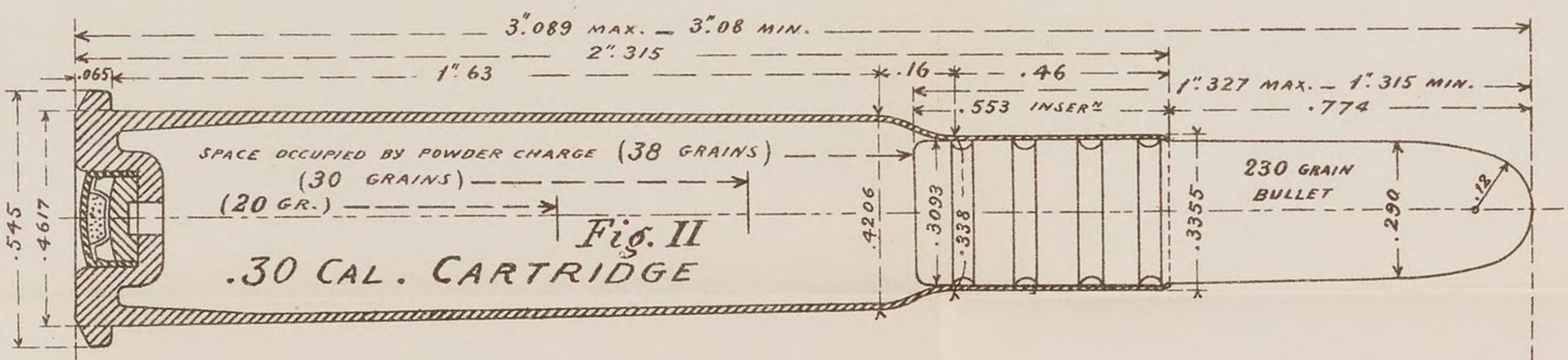


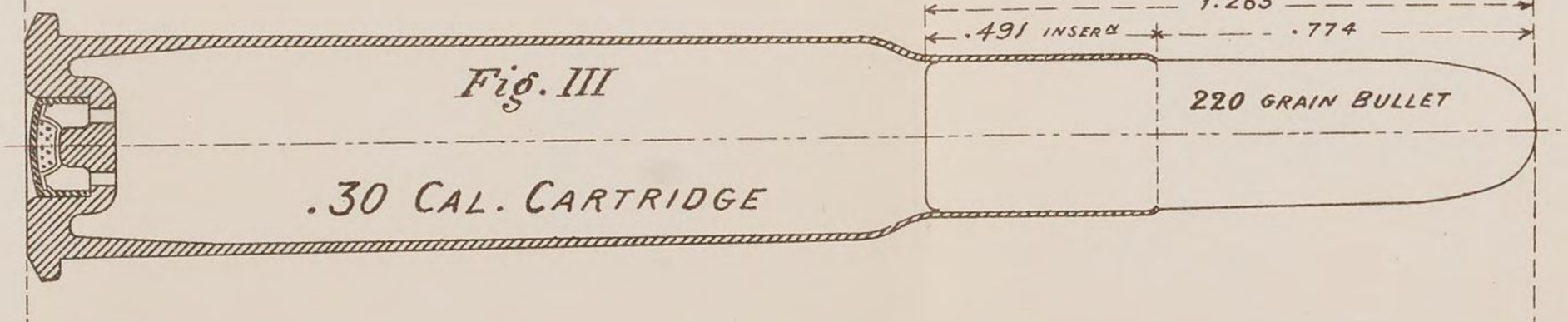
Maximum ordinates of 8.7, 5.3 and 4.2 feet, for the 500 Yard range at once indicate the danger space which is largely in the favor of the small calibers for all long ranges, the above figures increasing to 48, 34 and 29 feet respectively as shown in diagrams for 1000 Yds. range.

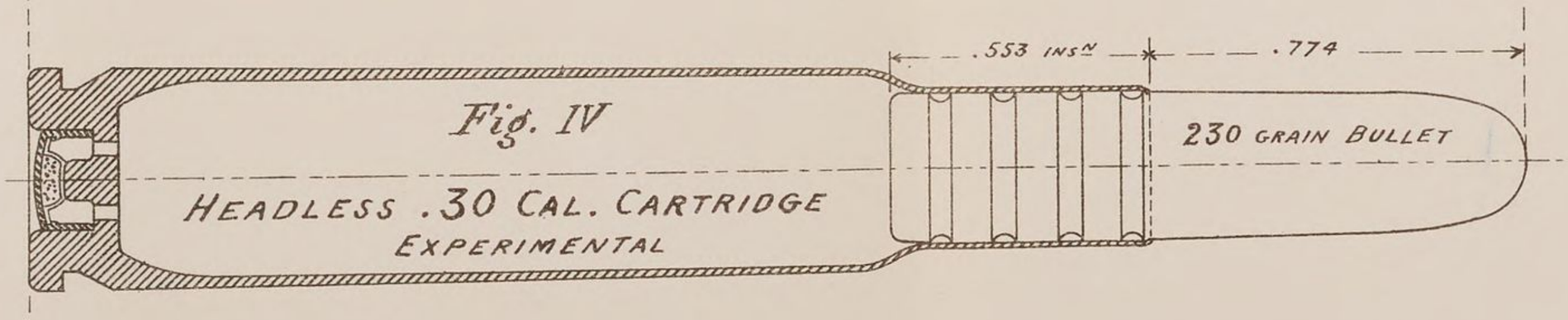
Gun	Wt. of Gun LBS.	Wt. of Ball GRAINS	APPROXIMATE RECOIL FT. LBS.
SPRINGFIELD RIFLE CAL. 45	8.8	500	15.33
RUBIN RIFLE CAL. 295	9.375	217	5.189
SPRINGFIELD RIFLE CAL. 30	8.79	230	7.676
SPRINGFIELD RIFLE CAL. 30	8.79	220	7.023

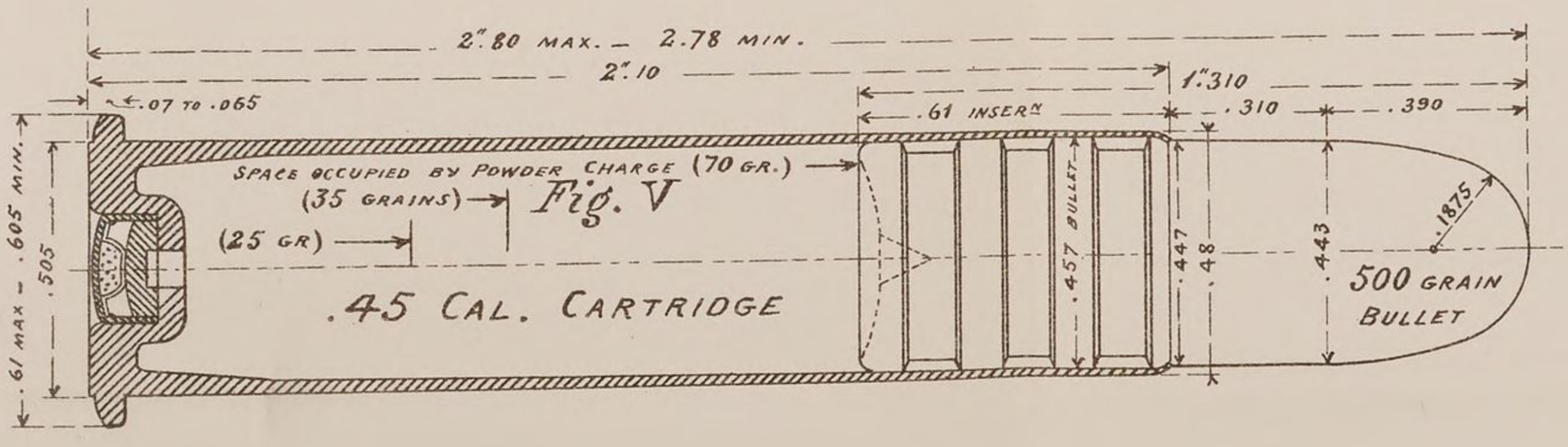
RIFLE CARTRIDGES AND CHAMBERS

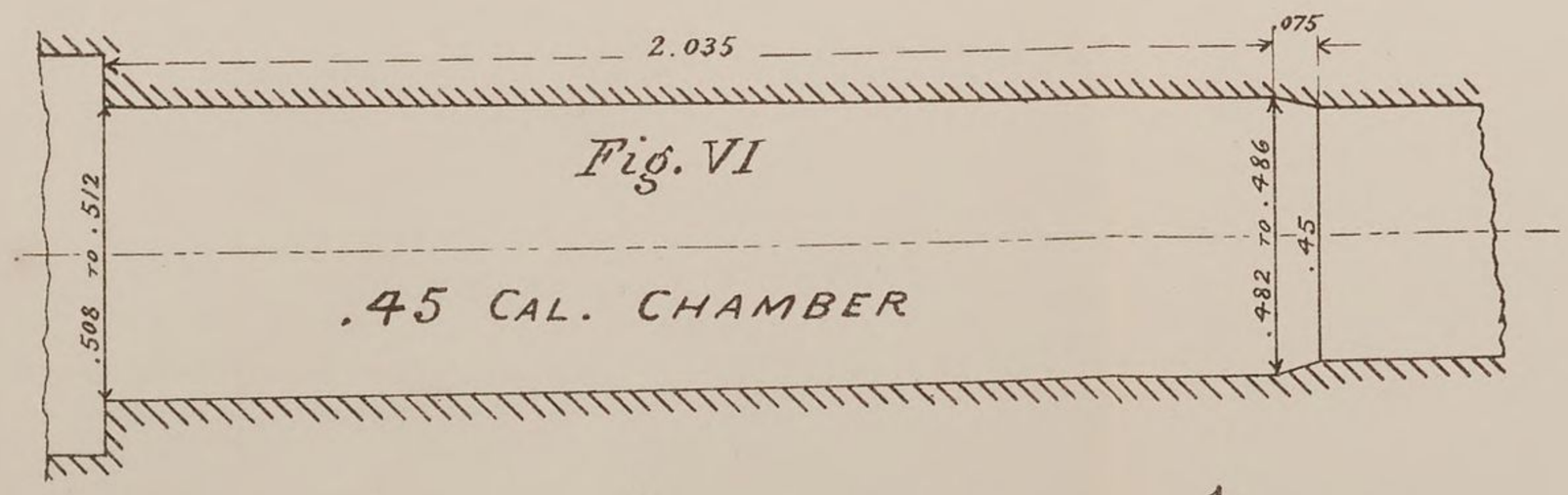


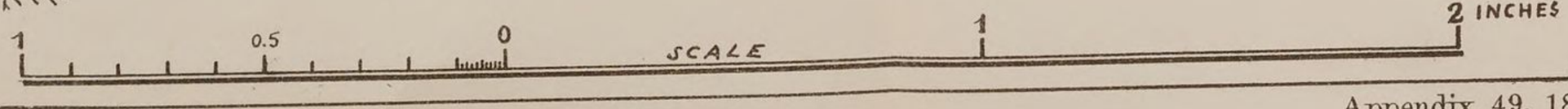












Appendix 49, 1893.

BULLETS.

Fig. I

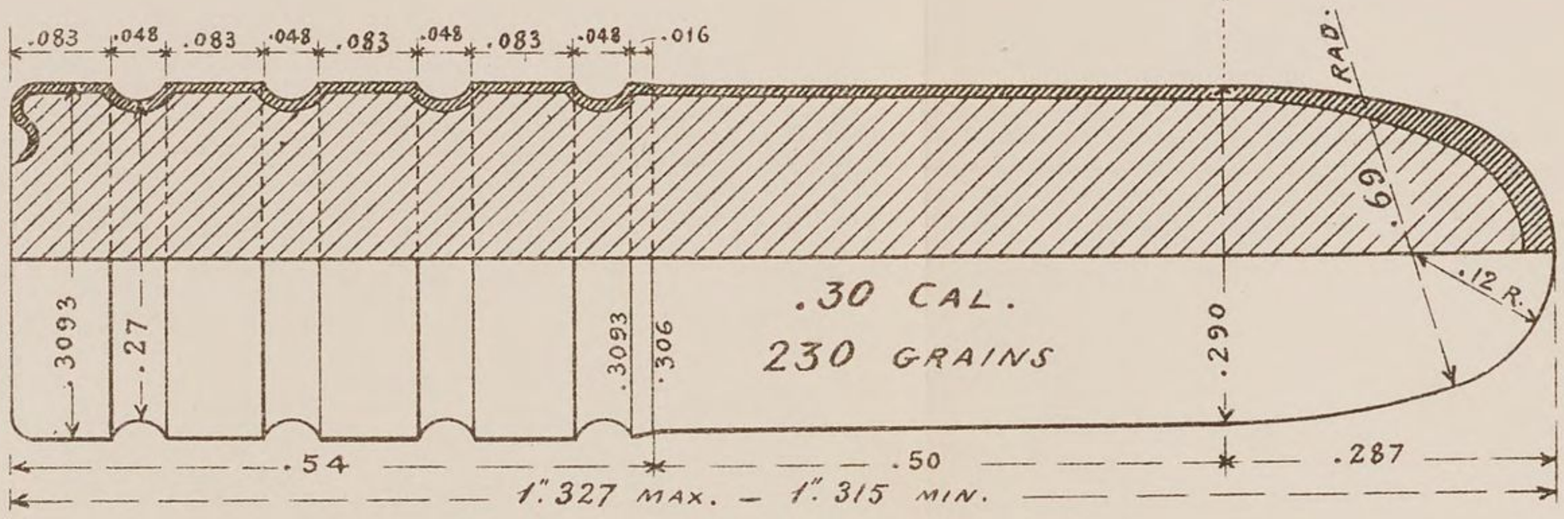


Fig. II

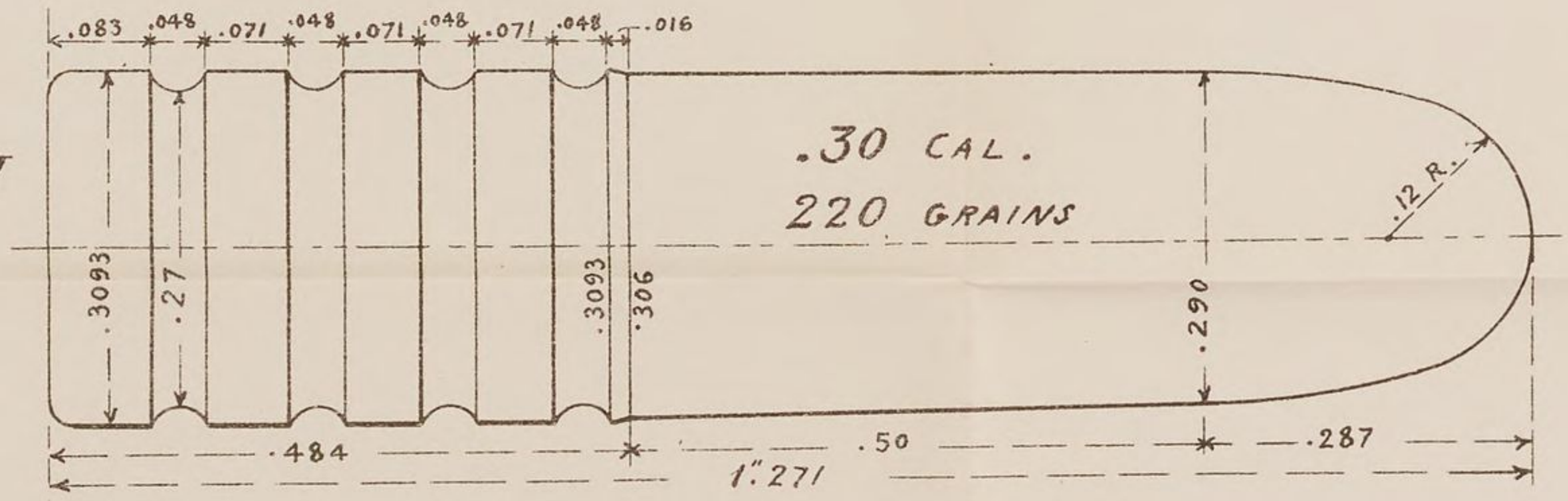


Fig. III

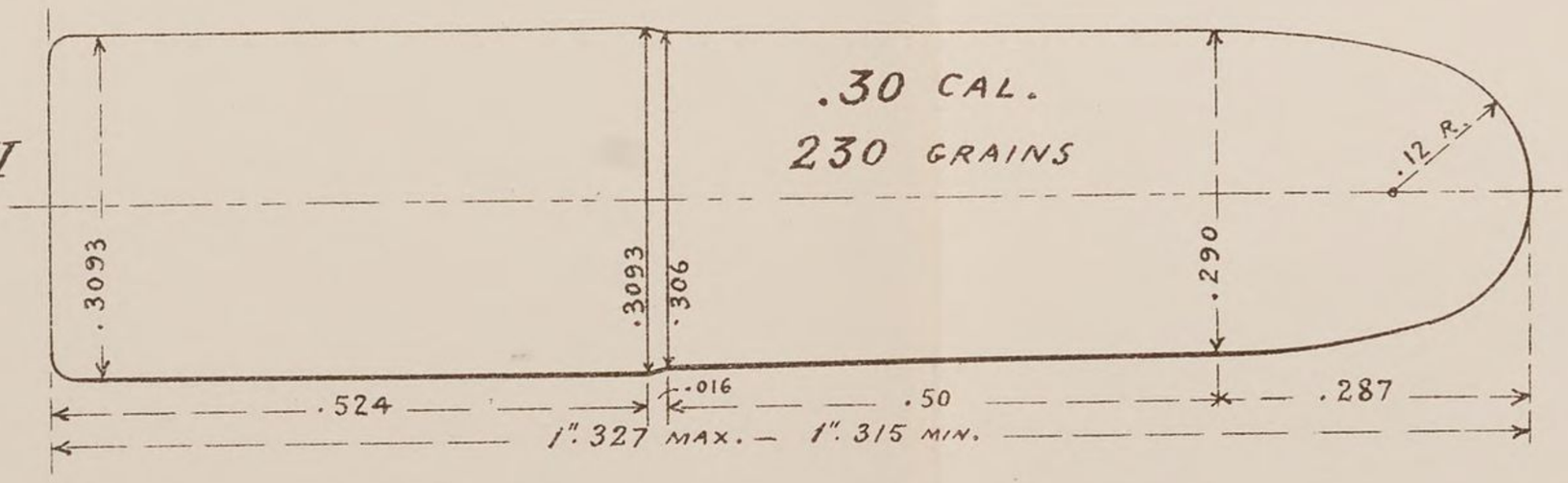


Fig. IV

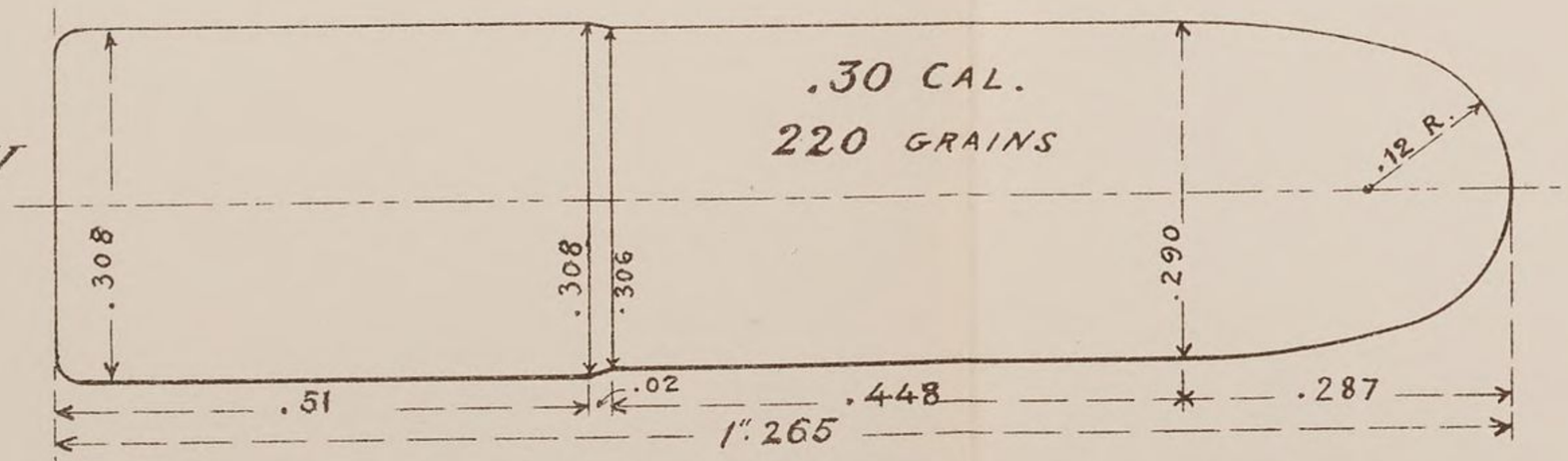
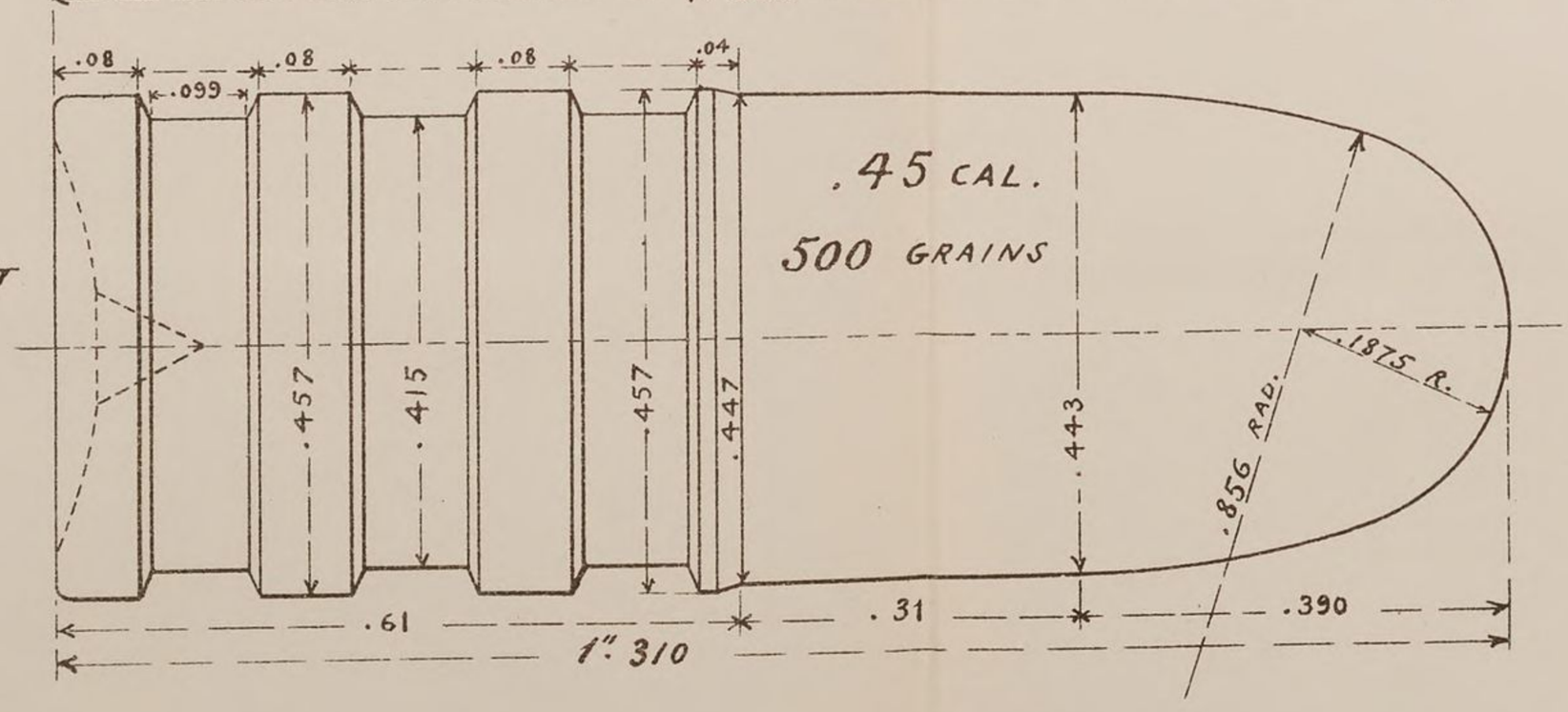
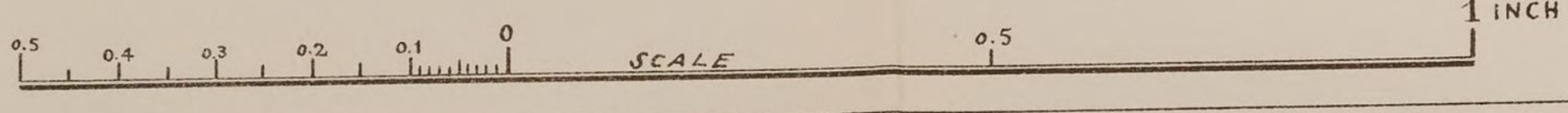
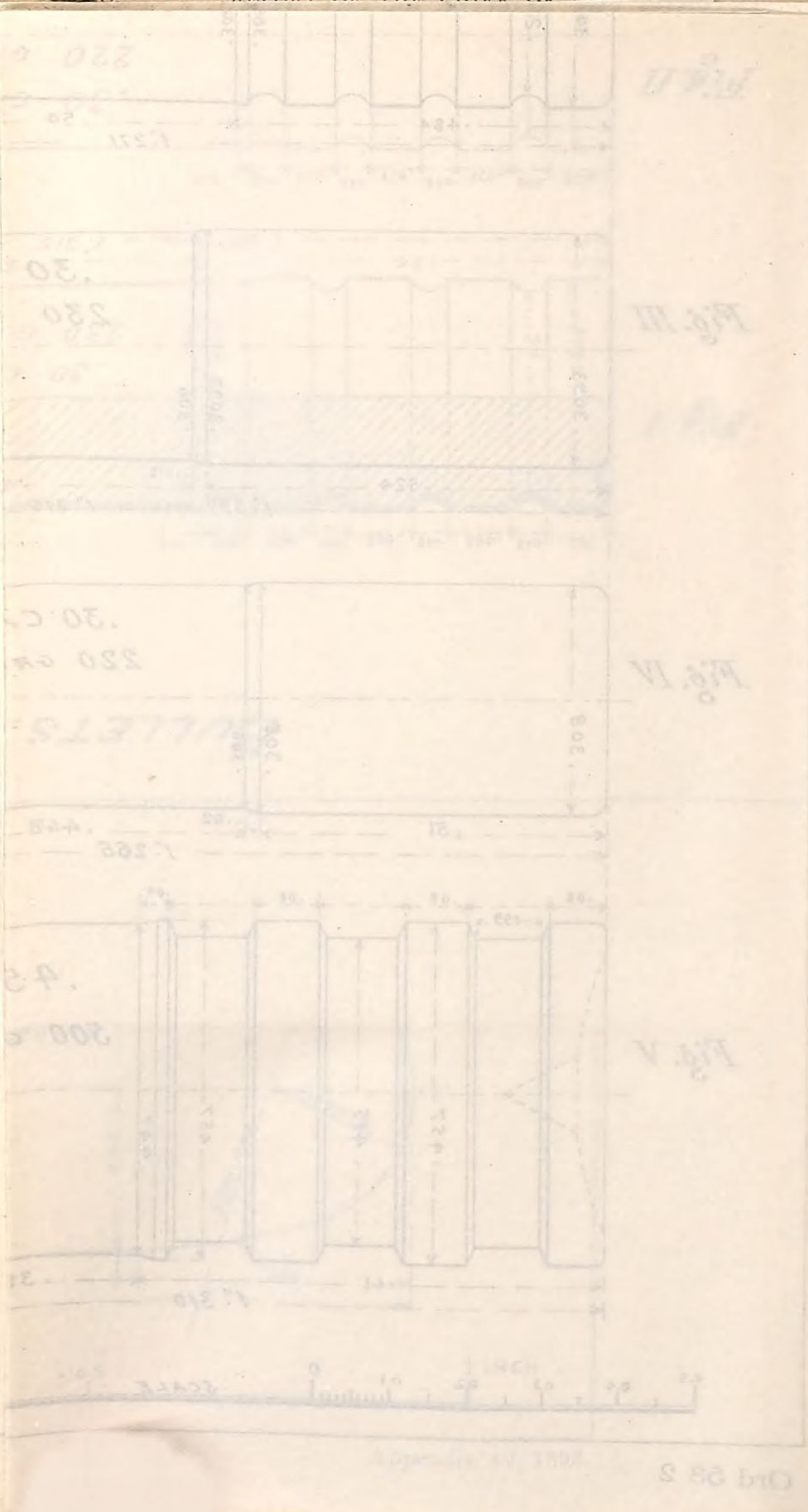


Fig. V







INDEX.

Page.

AMERICAN PROJECTILE COMPANY:
manufacture of electrically welded 3.2-inch shrapnel.....(Appendix 40) 541
AMMUNITION, RIFLE, CALIBER .30..... 20
report on manufacture of.....(Appendix 15) 267
ANDERSON, CAPT. GEORGE S.:
member of Board on Magazine Arms 132
relieved 144
ANNUAL REPORT:
chief ordnance officer Department of the Platte.....(Appendix 38) 525
APPENDICES:
Appendix 1.—Statement of principal articles procured by fabrication during the year ended June 30, 1893 55
2.—Statement of principal articles procured by purchase during the year ended June 30, 1893 66
3.—Statement of ordnance, ordnance stores, etc., issued to the Military Establishment, including the National Homes for soldiers of the volunteer and regular Army and exclusive of the militia, during the year ended June 30, 1893..... 86
4.—Statement of ordnance, ordnance stores, etc., distributed to the militia from July 1, 1892, to June 30, 1893, under section 1667, Revised Statutes..... 114
5.—Statement of ordnance, ordnance stores, etc., distributed to the colleges from July 1, 1892, to June 30, 1893, under section 1225, Revised Statutes..... 121
6.—Statement of arms and ammunition issued to the Executive Departments during the year ended June 30, 1893, under the provisions of the act of March 3, 1879..... 123
7.—Report of action taken during the year ended June 30, 1893, under the provisions of the act approved March 3, 1881.. 124
8.—Showing the stations and duties of the officers of the Ordnance Department..... 125
9.—Report of the board of officers convened under act of Congress approved February 27, 1893, to test magazine rifles of American invention (7 plates) 127
10.—Report of the board of officers on caliber, rifling, sights, and ammunition for the magazine rifle, model 1892..... 193

REPORTS FROM SPRINGFIELD ARMORY.

11.—Report of principal operations, with specifications for steam-power plant 197
12.—Specifications and plans for officers' quarters (9 plates).... 219
13.—Description and rules for management of Colt's revolver, caliber .38, army, model 1892 (4 plates) 235

REPORTS FROM FRANKFORD ARSENAL.

14.—Tests of smokeless powders for small arms (1 plate)..... 245
15.—Progress report on manufacture of .30 caliber ammunition (2 plates)..... 267
16.—Laboratory investigations of powders and explosives (2 plates) 275
17.—Manufacture of cannon friction primers (1 plate)..... 279
18.—Frankford Arsenal star gauge, model 1893 (5 plates)..... 283
19.—Effect of small-caliber rifle projectiles upon animal tissue and bone (23 plates) 287
20.—Methods and appliances for ballistic work (6 plates) 303

REPORTS FROM WATERVLIET ARSENAL AND ARMY GUN FACTORY.

APPENDICES—Continued. Page.
Appendix 21.—Report of principal operations (10 plates) 307
22.—Construction report on 3.6-inch mortar carriage, platform, etc. (1 plate) 325
23.—Specifications for highway bridge 327
24.—Specifications for machine tools 331
25.—Specifications for electric lighting 349

REPORTS FROM ROCK ISLAND ARSENAL.

26.—Report of principal operations (5 plates) 367

REPORTS FROM WATERTOWN ARSENAL.

27.—Report of principal operations (5 plates) 373
28.—Barbette carriage for 8-inch B. L. rifle (14 plates) 379

REPORTS FROM ORDNANCE PROVING GROUND.

29.—Report of principal operations (2 plates) 381
30.—Tests of smokeless powder for cannon 395

CONSTRUCTION OF ORDNANCE.

31.—Progress report on manufacture of steel forgings, etc., at the Bethlehem Iron Works, South Bethlehem, Pa 407
32.—Progress report on manufacture of steel forgings, etc., at the Midvale Steel Works, Philadelphia, Pa 411
33.—Progress report on manufacture of mortars and mortar carriages at the Builders' Iron Foundry, Providence, R. I. (1 plate) 451
34.—Progress report on the manufacture of ordnance at the West Point Foundry, Cold Spring, N. Y 467

REPORTS OF BOARD FOR TESTING RIFLED CANNON, ETC.

35.—Final report of test of 12-inch B. L. cast-iron rifle, steel half tube (1 plate) 469
36.—Final report of test of Hotchkiss 3-inch mountain gun 483

REPORTS OF ORDNANCE BOARD.

37.—Report on water-proof covering for field cartridges 517

MISCELLANEOUS.

38.—Annual report of chief ordnance officer Department of the Platte 525
39.—Frankford Arsenal 3.6-inch shrapnel (8 plates) 531
40.—American Projectile Company's 3.2-inch shrapnel (8 plates). 541
41.—Fuse punch for Frankford Arsenal point combination fuse (1 plate) 547
42.—New positive feed for Gatling machine gun (3 plates) 549
43.—The modern infantry rifle, by Capt. S. E. Blunt, Ordnance Department, U. S. Army (3 plates) 553
44.—Modern gun construction and breech mechanism, by Capt. Rogers Birnie, Ordnance Department, U. S. Army (8 plates). 583
45.—Disappearing gun carriage, by Capt. W. B. Gordon, Ordnance Department, U. S. Army (13 plates) 619
46.—The manufacture of steel for modern guns and other ordnance purposes, by Lieut. S. E. Stuart, Ordnance Department, U. S. Army 645
47.—Rapid-fire guns, by Lieut. E. St. J. Greble, Second Artillery, U. S. Army 659
48.—Strength of iron and steel at high temperatures, by Mr. James E. Howard, Watertown Arsenal, Mass. (2 plates) 697
49.—Recoil of small arms with charges of black and smokeless powders (8 plates) 707

		Page.
ARMING AND EQUIPPING THE MILITIA		5
ARMY GUN FACTORY		8
construction of 3.6 inch mortar carriage platforms, etc	(Appendix 22)	325
construction work, buildings, plant, etc	(Appendix 21)	307
ARMY:		
issues of stores to	(Appendix 3)	86
ARMAMENT OF FORTIFICATIONS		29
tests of powders with 8, 12, 4.7, 5 inch wire, 3.2-inch field guns, etc		29–33
seacoast guns		33
experimental guns		34
Brown segmental wire gun		36
mortars		39
gun carriages		40
alterations of carriages		41
mortar carriages		41
projectiles		42
pneumatic dynamite guns		43
siege material		43
siege and field projectiles		45
principal estimates for fiscal year 1895		47
progress report—manufactures at Bethlehem Iron Works	(Appendix 31)	407
Midvale Steel Works	(Appendix 32)	411
Builders' Iron Foundry	(Appendix 33)	451
West Point Foundry	(Appendix 34)	467
barbette carriage for 8-inch B. L. rifle, Watertown Arsenal	(Appendix 28)	379
final test of 12-inch B. L. cast-iron rifle, steel half tube	(Appendix 35)	469
modern gun construction and breech mechanism, by Capt. Rogers Birnie (Appendix 44)		583
disappearing gun carriages, by Capt. W. B. Gordon	(Appendix 45)	619
manufacture of steel for modern guns, by Lieut. S. E. Stuart	(Appendix 46)	645
rapid-fire guns, by Lieut. E. St. J. Greble	(Appendix 47)	659
strength of iron and steel at high temperatures	(Appendix 48)	697
report on 3.6 inch mortar-carriage platform, etc.	(Appendix 22)	325
ARNOLD, MAJ. ISAAC, JR.:		
report of principal operations at the Watervliet Arsenal	(Appendix 21)	307
member of Board for Testing Rifled Cannon, etc	(Appendix 36)	483
AYRES, CAPT. J. C.:		
annual report Department of the Platte	(Appendix 38)	525
BAKER, CAPT. FRANK:		
manufacture of cannon friction primers at Frankford Arsenal	(Appendix 17)	279
the Frankford Arsenal star gauge, model 1893	(Appendix 18)	283
description of the Frankford Arsenal 3.6-inch shrapnel and results of tests. (Appendix 39)		531
BALLISTIC WORK:		
methods and appliances, by Lieut. R. G. Paxton		303
BARBETTE CARRIAGE:		
for 8-inch B. L. rifle (Watertown Arsenal)	(Appendix 28)	379
BATES, COL. J. C., SECOND INFANTRY:		
member of Board on Magazine Guns		144
BENÉT, LIEUT. J. W.:		
member of board on rifling, etc., for the magazine rifle, model 1892. (Appendix 10)		193
report on effect of small caliber projectiles upon animal tissues and bone. (Appendix 19)		287
experiments upon the velocity of bullets by cutting off the barrel of the experimental rifle, caliber .30	(Appendix 49)	720
BENJ. ATHA & ILLINGWORTH COMPANY'S WORKS:		
manufacture of steel forgings	(Appendix 32)	427
BENICIA ARSENAL		15
BETHLEHEM IRON WORKS:		
manufacture of steel forgings	(Appendix 31)	407
BIRNIE, CAPT. ROGERS:		
calculated results of the use of smokeless powders—recoil, etc		257
modern gun construction and breech mechanism	(Appendix 44)	583
BLANKET-ROLL SUPPORT		48
BLAKE MAGAZINE ARM. (*See* Magazine arms.)		
BLUNT, CAPT. S. E.:		
member of Board on Magazine Guns		132

		Page.
BLUNT, CAPT. S. E.—Continued.		
member of board on caliber, rifling, sights, ammunition, etc., for the magazine gun, model 1892	(Appendix 10)	193
on the modern infantry rifle	(Appendix 43)	553
BOARDS:		
on trials and tests of magazine rifles for the Army, etc	(Appendix 9)	127
on rifling, caliber, ammunition, etc., for the magazine rifle, model 1892. (Appendix 10)		193
reports of Ordnance Board	(Appendix 37)	517
reports of Board for Testing Rifled Cannon, etc.	(Appendices 35 and 36)	469, 483
BREECH MECHANISM:		
by Capt. Rogers Birnie	(Appendix 44)	583
BROWN SEGMENTAL WIRE GUN		36
BUFFINGTON, COL. A. R.:		
report of principal operations at Rock Island Arsenal	(Appendix 26)	367
BUILDERS' IRON FOUNDRY:		
manufacture of mortars and mortar carriages	(Appendix 33)	451
CARRIAGES. (*See* Gun carriages.)		
CLERICAL FORCE OF ORDNANCE OFFICE		4
COLLEGES:		
issues of stores to	(Appendix 5)	121
COLT'S REVOLVER, CALIBER .38, model 1892, double action		20
description of, and rules for management, etc	(Appendix 13)	235
description of solid head reloading cartridge for		243
COLUMBIAN EXPOSITION:		
machines from Springfield Armory		210
COMLY, MAJ. CLIFTON:		
member of Board for Testing Rifled Cannon, with reports (Appendices 35 and 36)		469, 483
CONSTRUCTION OF ORDNANCE:		
progress report on manufacture at Bethlehem Iron Works	(Appendix 31)	407
Midvale Steel Works	(Appendix 32)	411
Builders' Iron Foundry	(Appendix 33)	451
West Point Foundry	(Appendix 34)	467
modern gun construction, by Capt. Rogers Birnie	(Appendix 44)	583
CROZIER WIRE GUN, 10-INCH		36
DESCRIPTION:		
magazine rifle, model 1892 (United States)		575
DISAPPEARING GUN CARRIAGES	(Appendix 45)	619
DISTRICT OF COLUMBIA MILITIA		4
DURST MAGAZINE ARMS. (*See* Magazine arms.)		
ELECTRIC LIGHTING:		
specifications for light and power plant at Watervliet Arsenal. (Appendix 25)		349
specifications for one 2 and one 5 horse power electric motor at Watervliet Arsenal		364
ESTIMATES:		
for armament of fortifications, fiscal year 1895		47
EXECUTIVE DEPARTMENTS:		
issues of stores to	(Appendix 6)	123
EXPENDITURES:		
statement for the fiscal year 1893		3
FABRICATIONS:		
statement of	(Appendix 1)	55
FARLEY, LIEUT. COL. J. P.:		
member of Board on Magazine Guns		132
relieved		144
member of board on rifling, etc., for the magazine rifle, model 1892. (Appendix 10)		193
report on smokeless powders	(Appendix 14)	245
report on manufacture of caliber .30 ammunition	(Appendix 15)	267
on recoil of caliber .45 and caliber .30 rifles with black and with smokeless powders	(Appendix 49)	707
FIELD CARRIAGE:		
for rapid-fire guns (Hotchkiss)	(Appendix 47)	693
FIELD MORTAR CARRIAGES:		
report of manufacture of 3.6 inch	(Appendix 22)	325
FISCAL STATEMENT, 1893		3

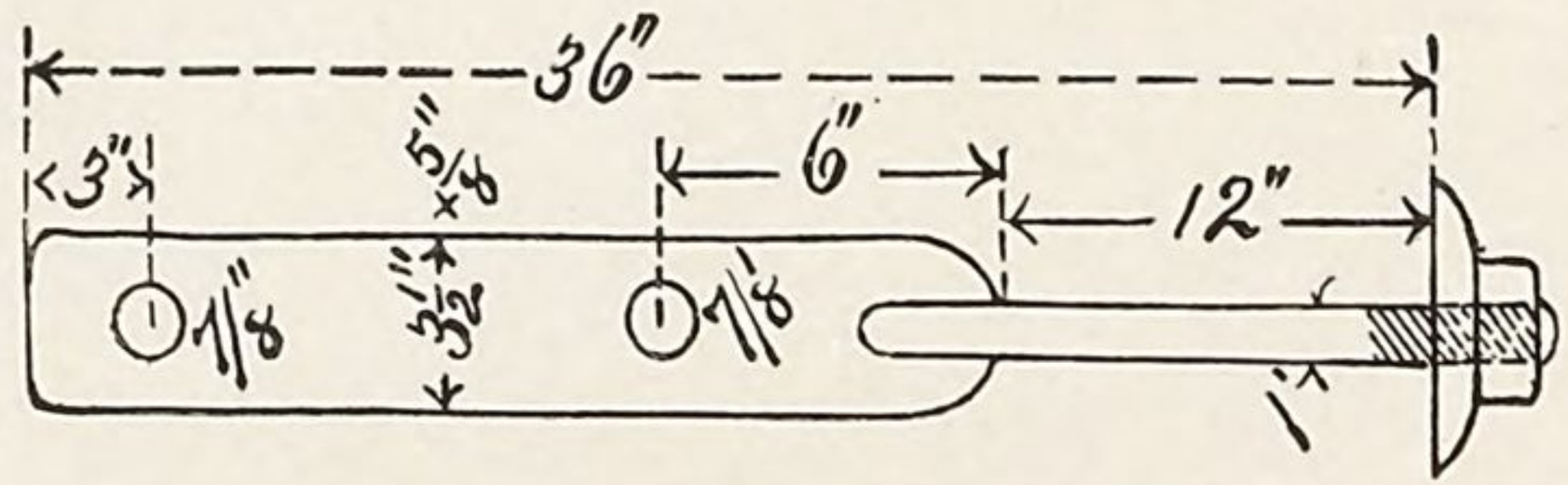
		Page.
FRANKFORD ARSENAL		14
ammunition for caliber .30 rifles (magazine)		20
tests of smokeless powders for small arms	(Appendix 14)	245
manufacture of caliber .30 ammunition	(Appendix 15)	267
laboratory investigations of powders and explosives	(Appendix 16)	275
manufacture of cannon friction primers	(Appendix 17)	279
Frankford Arsenal star guage, model 1893	(Appendix 18)	283
effect of small caliber rifle projectiles upon animal tissue and bone	(Appendix 19)	287
methods and appliances for ballistic work	(Appendix 20)	303
Frankford Arsenal 3.6 inch shrapnel	(Appendix 39)	531
fuse punch for Frankford Arsenal point combination fuse	(Appendix 41)	547
FREEMAN, MAJ. H. B.:		
member of Board on Magazine Guns		132
FRICTION PRIMERS, CANNON:		
manufacture of, at Frankford Arsenal	(Appendix 17)	279
FUSE PUNCH:		
for Frankford Arsenal point combination fuse	(Appendix 41)	547
GATLING GUN:		
machine, caliber .30		16
the new positive feed for	(Appendix 42)	549
GIBSON, LIEUT. W. W.:		
report on the manufacture of 3.2-inch shrapnel by the American Projectile Company	(Appendix 40)	541
GIRTH ATTACHMENT		48
GORDON, CAPT. W. B.:		
progress report on manufacture of ordnance at West Point Foundry. (Appendix 34)		467
on disappearing gun carriages	(Appendix 45)	619
GREBLE, LIEUT. E. ST. J.:		
on rapid-fire guns	(Appendix 47)	659
GUN CARRIAGES		40
alterations of, and mortar carriages		41
barbette for 8-inch B. L. rifle	(Appendix 28)	379
manufacture of, at works of the Builders' Iron Foundry	(Appendix 33)	451
disappearing	(Appendix 45)	619
GUN-CARRIAGE FACTORY AT WATERTOWN ARSENAL		6
GUN CONSTRUCTION:		
modern, by Capt. Rogers Birnie	(Appendix 44)	583
HALL, LIEUT. COL. ROBERT H.:		
member of Board on Magazine Guns		132
HAMPDEN MAGAZINE RIFLE. (*See* Magazine arms.)		
HEATH, CAPT. FRANK:		
report of principal operations at Sandy Hook Proving Ground. (Appendix 29)		381
member of Board on Testing Rifled Cannon	(Appendices 35 and 36)	469, 483
report of firing tests of 3.2-inch shrapnel (American Projectile Company)		544
HOBBS, CAPT. F. E.:		
report on manufacture of 3.6-inch B. L. field-mortar carriages, platform, and implements at Watervliet Arsenal	(Appendix 22)	325
HOTCHKISS 3-INCH B. L. MOUNTAIN RIFLE:		
final report on test of, by the Board for Testing Rifled Cannon. (Appendix 36)		483
HOTCHKISS FIELD CARRIAGE:		
for rapid-fire guns, description of		693
HOWARD, J. E.:		
on the strength of iron and steel at higher temperatures	(Appendix 48)	697
INTRENCHING TOOLS		48
INVENTORS:		
circular letter inviting improvements to the magazine gun, model 1892		205
ISSUES OF STORES:		
to the Army, National Homes, etc	(Appendix 3)	86
to the militia	(Appendix 4)	114
to colleges	(Appendix 5)	121
to the Executive Departments	(Appendix 6)	123
LEE, MODEL 1893, MAGAZINE RIFLE. (*See* Magazine arms.)		
LEE-SPEED MAGAZINE RIFLE:		
description, etc. (England)		570

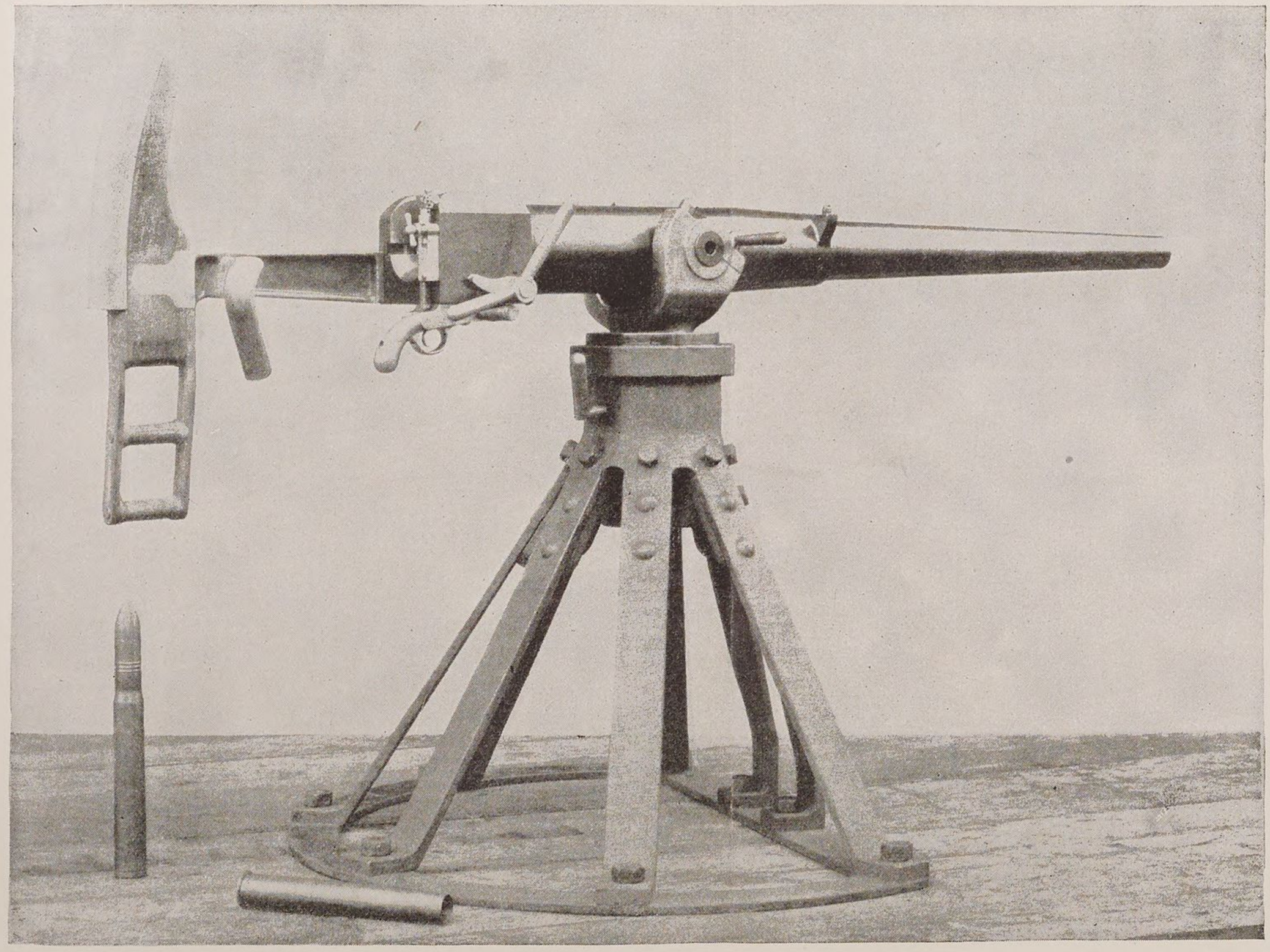
	Page.
LIST OF MAGAZINE RIFLES:	
submitted to Board on Magazine Arms	147
LYLE, CAPT. D. A.:	
report on manufacture of steel forgings at the Midvale Steel Works. (Appendix 32)	411
manufacture of steel forgings at the Benj. Atha & Illingworth Company's works, Newark, N. J (Appendix 32)	427
LYON, CAPT. M. W.:	
report on manufacture of mortars and mortar carriages at the Builders' Iron Foundry, Providence, R. I (Appendix 33)	451
MACHINE GUNS:	
the Gatling, caliber .30	16
MACHINE TOOLS:	
specifications for, at the Watervliet Arsenal (Appendix 24)	331
MACNUTT, CAPT. J.:	
report on manufacture of steel forgings at Bethlehem Iron Works. (Appendix 31)	407
MAGAZINE RIFLE, MODEL 1892, CALIBER .30	16
report of board on adoption of caliber, rifling, ammunition, etc. (Appendix 10)	193
circular letter to inventors inviting improvements	205
description of the adopted arm (United States)	575
MAGAZINE ARMS:	
on the modern infantry rifle, by Capt. S. E. Blunt (Appendix 43)	553
description of the magazine rifle, model 1892 (United States)	575
Lee-Speed (England)	570
Mannlicher (Roumania and Holland)	567
report of board to test rifles of American invention (Appendix 9)	127
members of the board	131
Part I.—Proceedings of the board	132
rules and tests governing the trials	133–136
arms may be received after March 31 and before May 1, 1893	143
Lieut. Col. J. P. Farley and Capt. Geo. S. Anderson, members, relieved	144
list of arms submitted, with address of exhibitors	147
Part II.—Descriptions of the arms before the board	148
Spencer-Lee gun	148
Lee, model 1893	150
Savage	150
Durst, No. 1	151
Durst, No. 2	155
Durst, No. 3	155
Durst, No. 4	155
Blake, No. 1	155
Russell-Livermore, No. 1	158
Russell Livermore, No. 2	159
Russell-Livermore, No. 3	160
White	160
Hampden	164
Blake, No. 2	166
Part III—Synopsis of the tests	167
Spencer-Lee and Lee, model 1893	167
Savage	169
Durst, Nos. 1, 2, and 3	171
Durst, No. 4	173
Blake, No. 1	173
Russell-Livermore, No. 1	175
Russell-Livermore, No. 2	176
Russell-Livermore, No. 3	177
White	178
Hampden	181
Blake, No. 2	184
table of results of trials	185
index to Appendix 9 (report of board)	191
MANNLICHER MAGAZINE GUN:	
description, etc. (Roumania and Holland)	567
MANUFACTURE OF STEEL:	
for modern guns, by Lieut. S. E. Stuart (Appendix 46)	645
METHODS AND APPLIANCES:	
for ballistic work (Appendix 20)	303

		Page.
MIDVALE STEEL WORKS:		
the manufacture of steel forgings	(Appendix 32)	411
MILITIA:		
appropriation for arming and equipping the		5
District of Columbia		4
issues of stores to	(Appendix 4)	114
MODERN GUN CONSTRUCTION:		
by Capt. Rogers Birnie	(Appendix 44)	583
MOORE, MAJ. FRANCIS:		
member of Board on Magazine Guns		144
MORDECAI, COL. ALFRED:		
report of principal operations at the Springfield Armory	(Appendix 11)	197
member of board on caliber, rifling, etc., for the magazine rifle, model 1892	(Appendix 10)	193
MORTARS		39
MORTAR CARRIAGES		41
report on manufacture of 3.6-inch platform, etc	(Appendix 22)	325
MORTARS AND CARRIAGES:		
report on the manufacture of, at the Builders' Iron Foundry, Providence, R. I.	(Appendix 33)	451
MOUNTAIN GUN MATERIAL		45
NOSEBAGS, ECONOMIC		48
ORDNANCE BOARD:		
report on results obtained by firing cartridges for field guns put up in water-proof cases	(Appendix 37)	517
OTIS, COL. ELWELL S.:		
member of Board on Magazine Guns		132
PAXTON, LIEUT. ROBERT G.:		
report on American and foreign smokeless powders		258
methods and appliances for ballistic work	(Appendix 20)	303
PECK, LIEUT. FREMONT P.:		
report on tests of smokeless powders for cannon	(Appendix 30)	395
member of Board for Testing Rifled Cannon, etc	(Appendix 36)	483
PEELER RASP		48
PITMAN, CAPT. J.:		
report on powders (laboratory investigations)	(Appendix 16)	275
PNEUMATIC DYNAMITE GUNS		43
PORTABLE PLATFORM SCALE:		
specifications for, at Watervliet Arsenal, capacity 300,000 pounds		365
PRINCIPAL OPERATIONS:		
Springfield Armory	(Appendix 11)	197
Watervliet Arsenal	(Appendix 21)	307
Rock Island Arsenal	(Appendix 26)	367
Watertown Arsenal	(Appendix 27)	373
Sandy Hook Proving Ground	(Appendix 29)	381
annual report chief ordnance officer Department of the Platte. (Appendix 38)		525
PROGRESS REPORTS:		
manufacture of steel forgings at Bethlehem Iron Works	(Appendix 31)	407
Midvale Steel Works	(Appendix 32)	411
Builders' Iron Foundry	(Appendix 33)	451
manufacture of ordnance at the West Point Foundry	(Appendix 34)	467
PROJECTILES:		
armor-piercing shot; deck-piercing shell		42
fuses		46
siege and field		45
small caliber—effect of, on animal tissue and bone	(Appendix 19)	287
PROVING GROUND. (*See* Sandy Hook.)		
PURCHASES:		
statement of	(Appendix 2)	66
of powder, smokeless	(Appendix 7)	124
RAPID-FIRE GUNS:		
by Lieut. E. St. J. Greble, Second U. S. Artillery	(Appendix 47)	659
RECEIPTS AND EXPENDITURES:		
fiscal year 1893		3
REILLY, MAJ. J. W.:		
principal operations at Watertown Arsenal	(Appendix 27)	373
member of Board on Testing Cannon	(Appendices 35 and 36)	469, 483

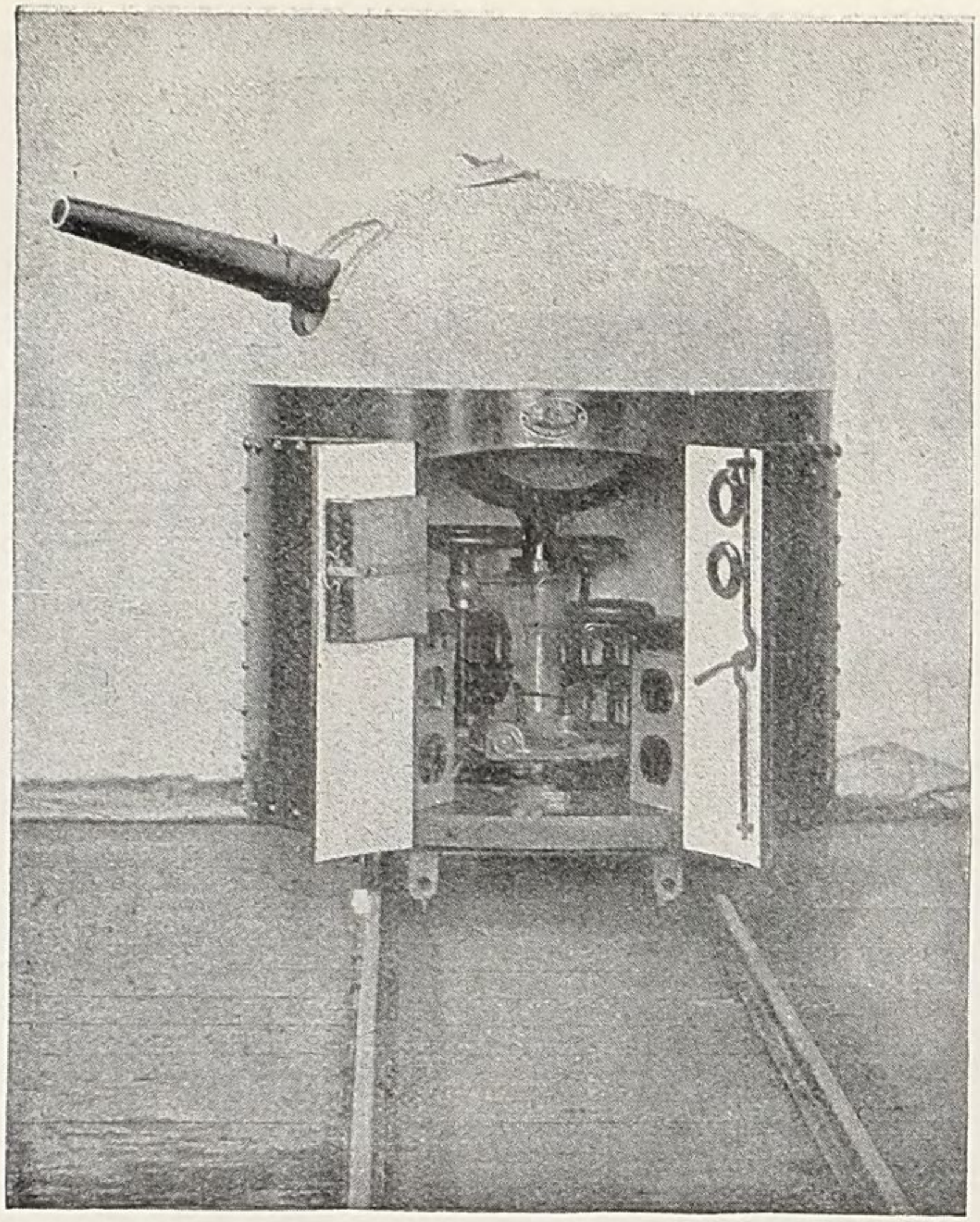
		Page.
ROCK ISLAND ARSENAL:		
report of principal operations	(Appendix 26)	367
powder cases for storing cartridges for B. L. rifles and mortars		367
reconstruction of floor systems of Rock Island bridge		369
ROSTER OF THE ORDNANCE DEPARTMENT	(Appendix 8)	125
RUSSELL-LIVERMORE MAGAZINE GUN. (*See* Magazine arms.)		
SALES:		
of cartridges under act of March 3, 1881	(Appendix 7)	124
may be made to inventors presenting arms to Board on Magazine Arms for trial		133
SANDY HOOK PROVING GROUND		11
report of principal operations	(Appendix 29)	381
specifications for removal and construction of a dock		385
tests of smokeless powder for cannon	(Appendix 30)	395
SAVAGE MAGAZINE GUN. (*See* Magazine arms.)		
SEACOAST GUN-CARRIAGE FACTORY:		
at Watertown Arsenal		6
SEACOAST GUNS		33
experimental 12-inch, cast-iron, tubed with steel		34
Woodbridge 10-inch wire gun		36
Crozier 10-inch wire gun		36
Brown segmental wire gun		36
SHRAPNEL, 3.6-INCH:		
description of the Frankford Arsenal, with results of tests	(Appendix 39)	531
SMALL-ARM AMMUNITION		20
SMALL-ARMS:		
report of board on trials of magazine guns to select one for adoption into the United States service	(Appendix 9)	127
the modern infantry rifle, by Capt. S. E. Blunt	(Appendix 43)	553
description of the magazine rifle, model 1892 (United States)		575
Lee-Speed (England)		570
Mannlicher (Roumania and Holland)		567
on the recoil of calibers .45 and .30 rifles using both black and smokeless powders	(Appendix 49)	707
SMALL-CALIBER PROJECTILES:		
effect of, on animal tissue and bone	(Appendix 19)	287
SMOKELESS POWDERS		24
tests of, for small-arms	(Appendix 14)	245
tests of, for cannon	(Appendix 30)	395
the Wetteren tests		246
the Peyton tests		248
the Leonard tests		249
the Du Pont tests		252
the Axtell tests		253
the Troisdorf tests		254
the Alters tests		255
the Rifleite tests		245
a report on smokeless powders for small arms, by Lieut. R. G. Paxton, Tenth Cavalry		258
laboratory investigations of powders and explosives, by Capt. J. Pitman. (Appendix 16)		275
tests of smokeless powders for cannon at Sandy Hook	(Appendix 30)	395
recoil of calibers .45 and .30 rifles of varying lengths with smokeless and black powders, varying weights of bullets, etc	(Appendix 49)	707
SOUTH BOSTON IRON WORKS:		
final report of Board on Testing Cannon (12-inch B. L. rifle, cast-iron, steel half tube	(Appendix 35)	469
SPECIFICATIONS:		
traveling cranes (60 and 30 ton), electric overhead, Watervliet Arsenal		354, 360
machine tools at Watervliet Arsenal	(Appendix 24)	331
electric lighting power and plant at Watervliet Arsenal	(Appendix 25)	349
paving at Watervliet Arsenal		316
2 and 5 horse power electric motor, Watervliet Arsenal		364
highway bridge at Watervliet Arsenal	(Appendix 23)	327
portable platform scale (300,000 pounds) at Watervliet Arsenal		365
steam power plant at Springfield Armory		212
officers' quarters at Springfield Armory		219
for removal of old and construction of new dock at Sandy Hook		385
SPENCER-LEE MAGAZINE RIFLE. (*See* Magazine arms).		

		Page.
SPRINGFIELD ARMORY		12
the manufacture of the caliber .30 magazine rifle, model 1892		16
report of principal operations	(Appendix 11)	197
specifications for steam-power plant		212
officers' quarters	(Appendix 12)	219
description of, and rules for, the management of Colt's double-action revolver, model 1892	(Appendix 13)	235
STAR GAUGE, MODEL 1893 (FRANKFORD ARSENAL)	(Appendix 18)	283
STATIONS AND DUTIES:		
ordnance officers on October 1, 1893	(Appendix 8)	125
STEEL FORGINGS:		
manufacture of, at Bethlehem Iron Works	(Appendix 31)	407
Midvale Steel Works	(Appendix 32)	411
on the manufacture of, for modern guns, by Lieut. Stuart	(Appendix 46)	645
STRENGTH OF IRON AND STEEL:		
at higher temperatures	(Appendix 48)	697
STUART, LIEUT. SIDNEY E.:		
on the manufacture of steel forgings for modern guns and other ordnance purposes	(Appendix 46)	645
TAYLOR, CAPT. D. M.:		
description of the fuse punch for Frankford Arsenal point combination fuse. (Appendix 41)		547
member of board on rifling, etc., for the magazine rifle, model 1892. (Appendix 10)		193
TESTS:		
magazine arms for a service arm	(Appendix 9)	127
smokeless powders	(Appendix 14)	245
report of Board on Testing Rifled Cannon	(Appendix 35)	469
THOMPSON, LIEUT. JOHN T.:		
report on manufacturing of powder cases for storing cartridges for B. L. rifles and mortars	(Appendix 26)	367
report on reconstruction of floor systems of the Rock Island bridge		369
TRAVELING CRANE		
the working of, at Watervliet Arsenal		319
specifications for a 60-ton, single trolley, electric, overhead, at Watervliet Arsenal		354
specifications for a 30-ton single trolley, electric, overhead		360
WATERTOWN ARSENAL:		
gun-carriage factory		6
report of principal operations	(Appendix 27)	373
barbette carriage for 8-inch B. L. rifle	(Appendix 28)	379
WATERVLIET ARSENAL:		
Army Gun Factory		8
report of principal operations	(Appendix 21)	307
construction report on 3.6-inch mortar carriage, platform, etc. (Appendix 22)		325
specifications for highway bridge	(Appendix 23)	327
paving		316
machine tools	(Appendix 24)	331
electric lighting, power and plant	(Appendix 25)	349
traveling cranes, single trolley, overhead		354, 360
2 and 5 horse power electric motor		364
portable platform scale (300,000 pounds)		365
WEST POINT FOUNDRY:		
manufacture of ordnance	(Appendix 34)	467
WHEELER, LIEUT. CHARLES B.:		
member of Board for Testing Rifled Cannon	(Appendix 35)	469
WHITE MAGAZINE GUN. (*See* Magazine arms.)		
WILSON, T. B.:		
submits Hampden magazine gun		147
WOODBRIDGE 10-INCH WIRE GUN		36

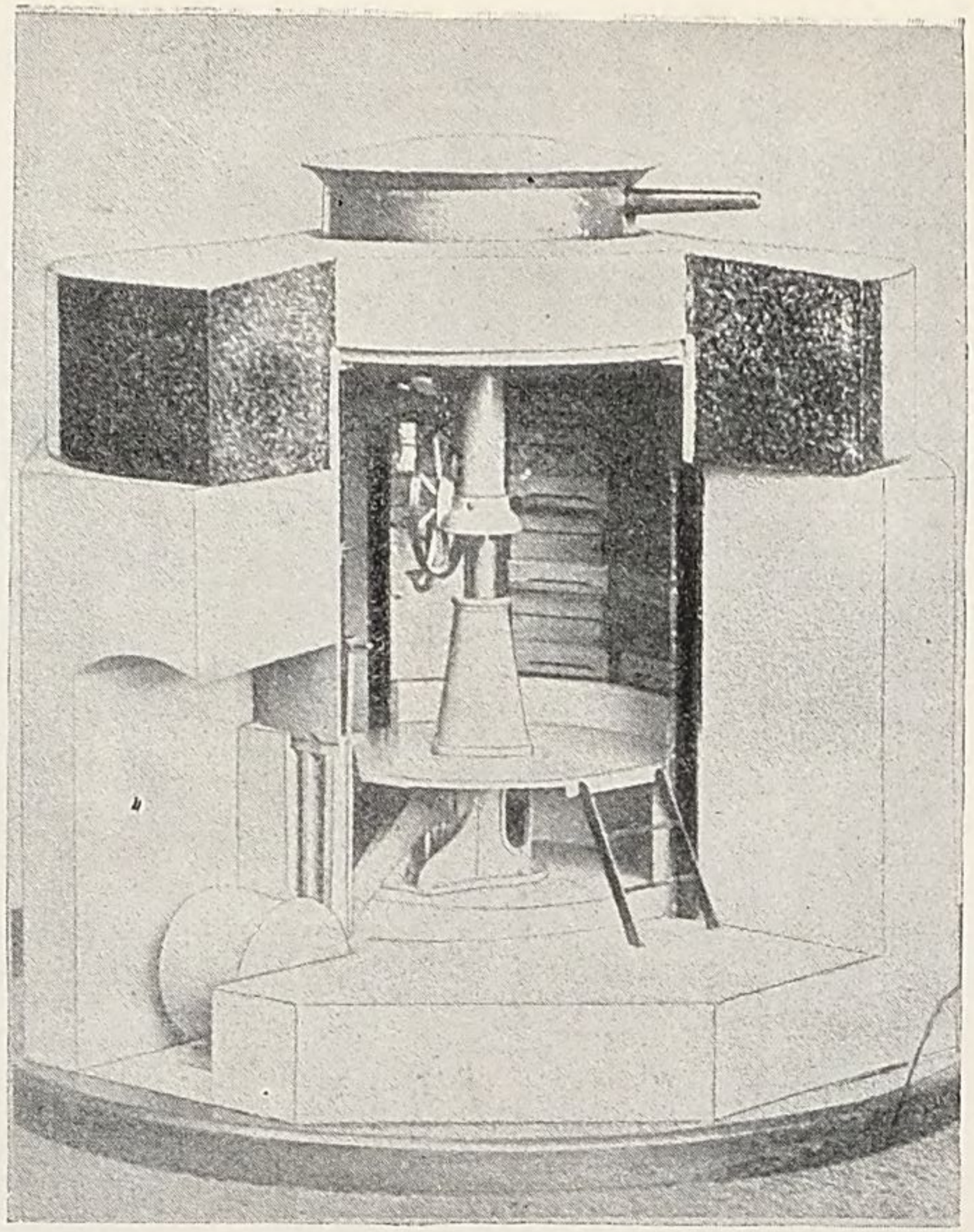

36"
3"
5/8"
6"
12"
1 1/8"
3 1/2"
1 1/8"
1"



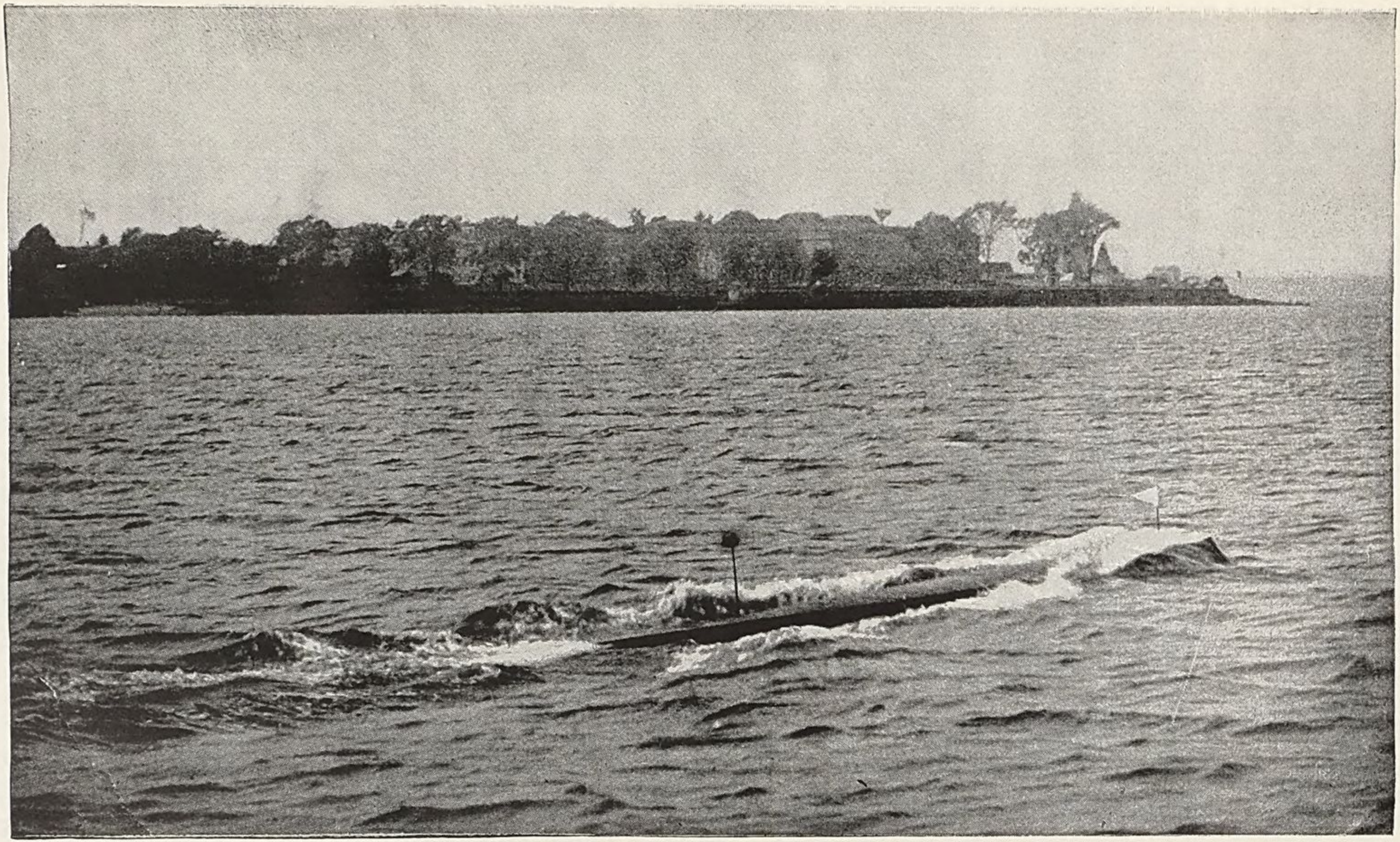
3 Pdr. Hotchkiss on Crinoline Mount.



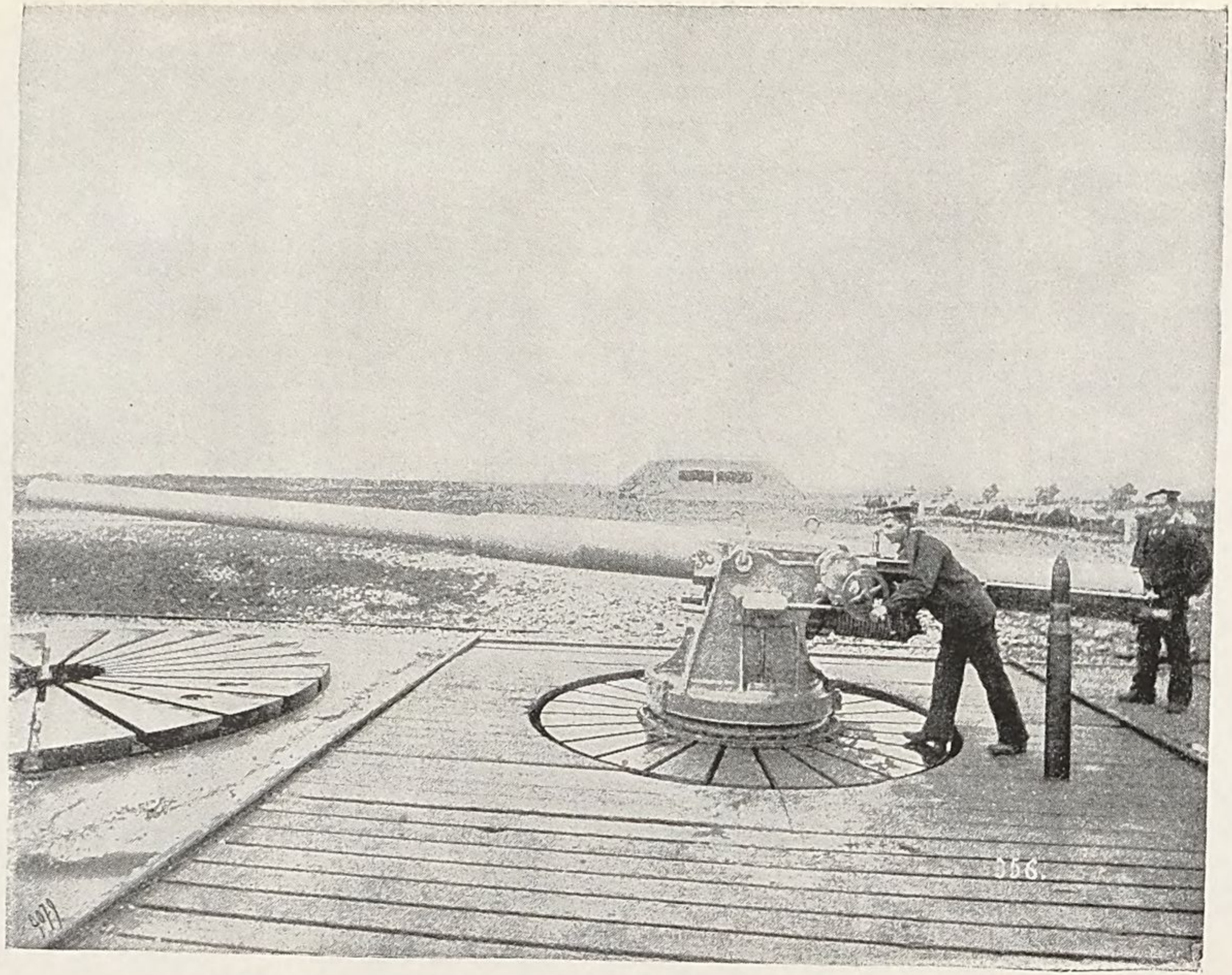
MOVABLE SHIELDED MOUNTING FOR 2.24 INCH 25 CALIBRE R. F. GUN. (GRUSON.)



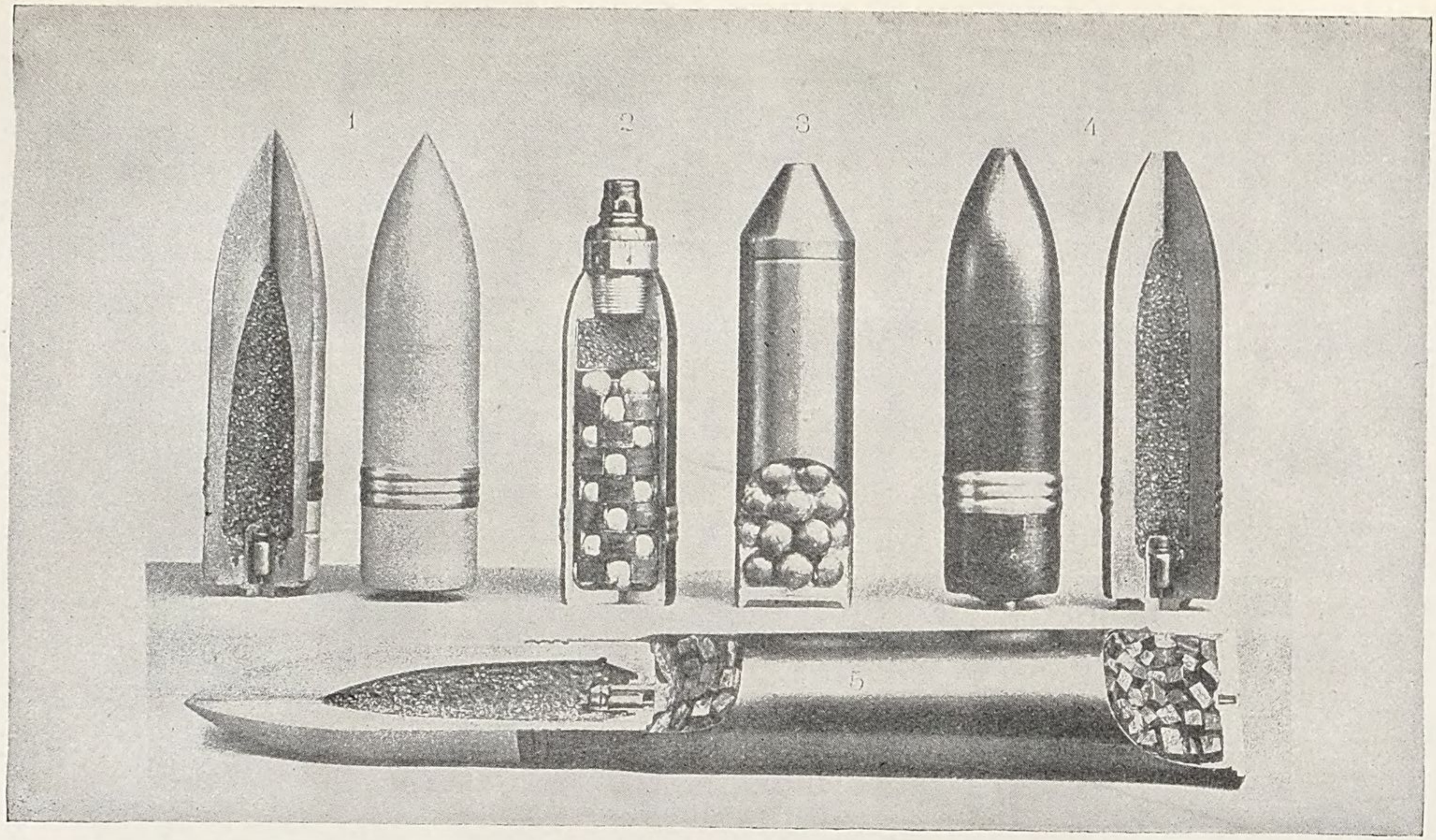
DISAPPEARING SHIELDED MOUNTING FOR 2.09″ 24 CALIBRE R. F. GUN. (GRUSON.)



SIMS FISH IN MOTION, JULY 15, 1890.
Speed about 18 miles per hour.

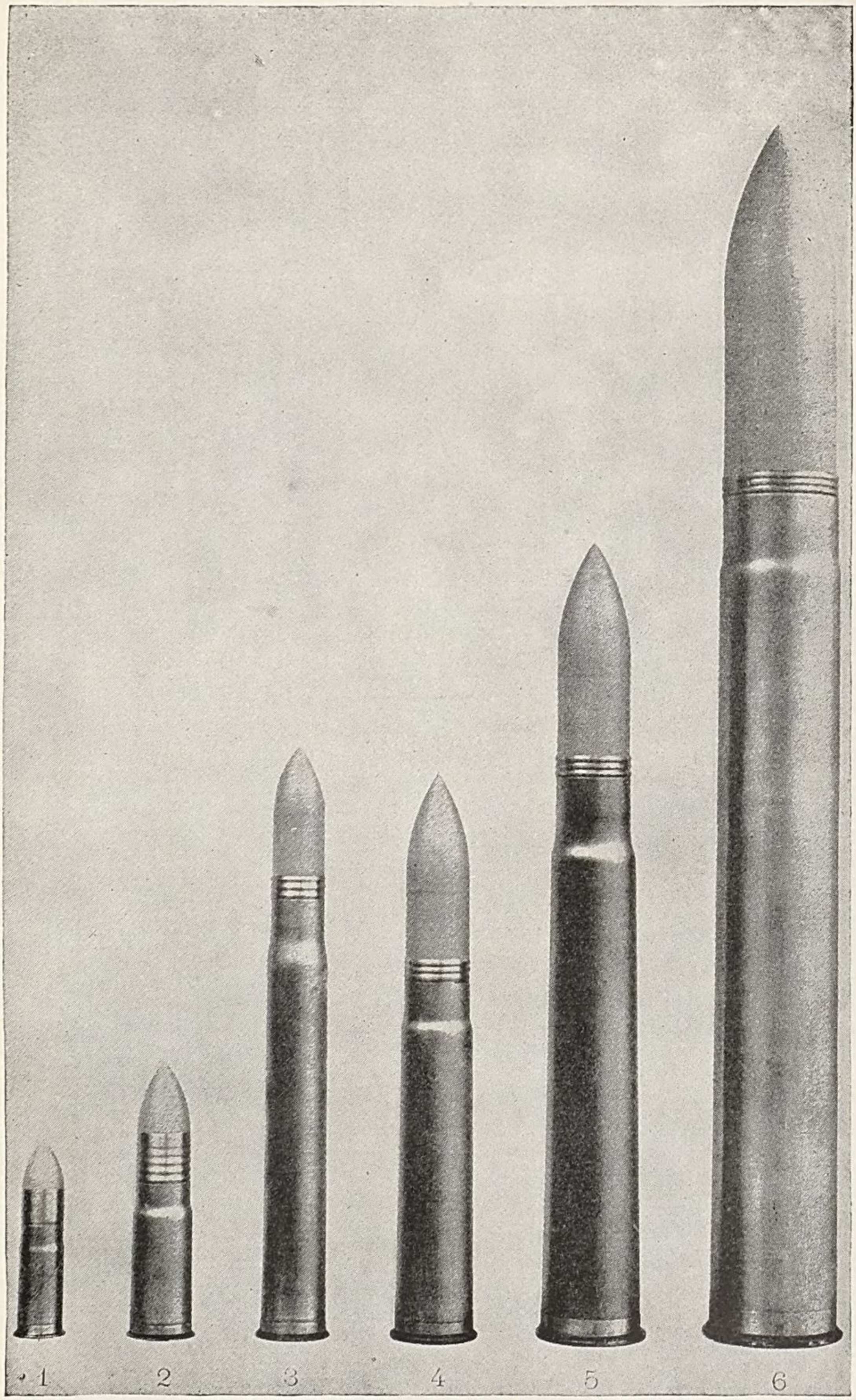


CANET 10cm 80 CALIBRE R. F. GUN.

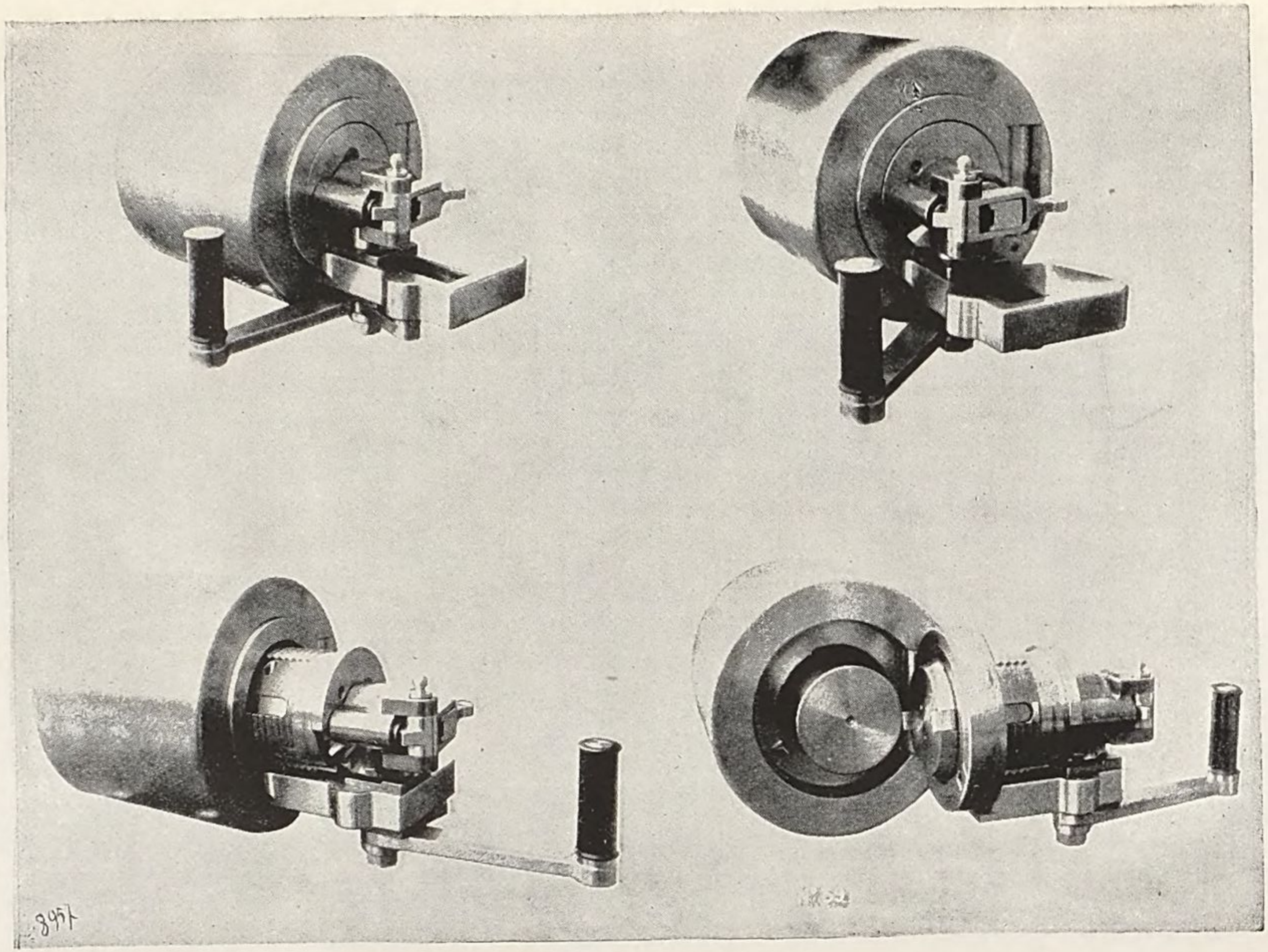


R. F. AMMUNITION IN SECTION. HOTCHKISS.

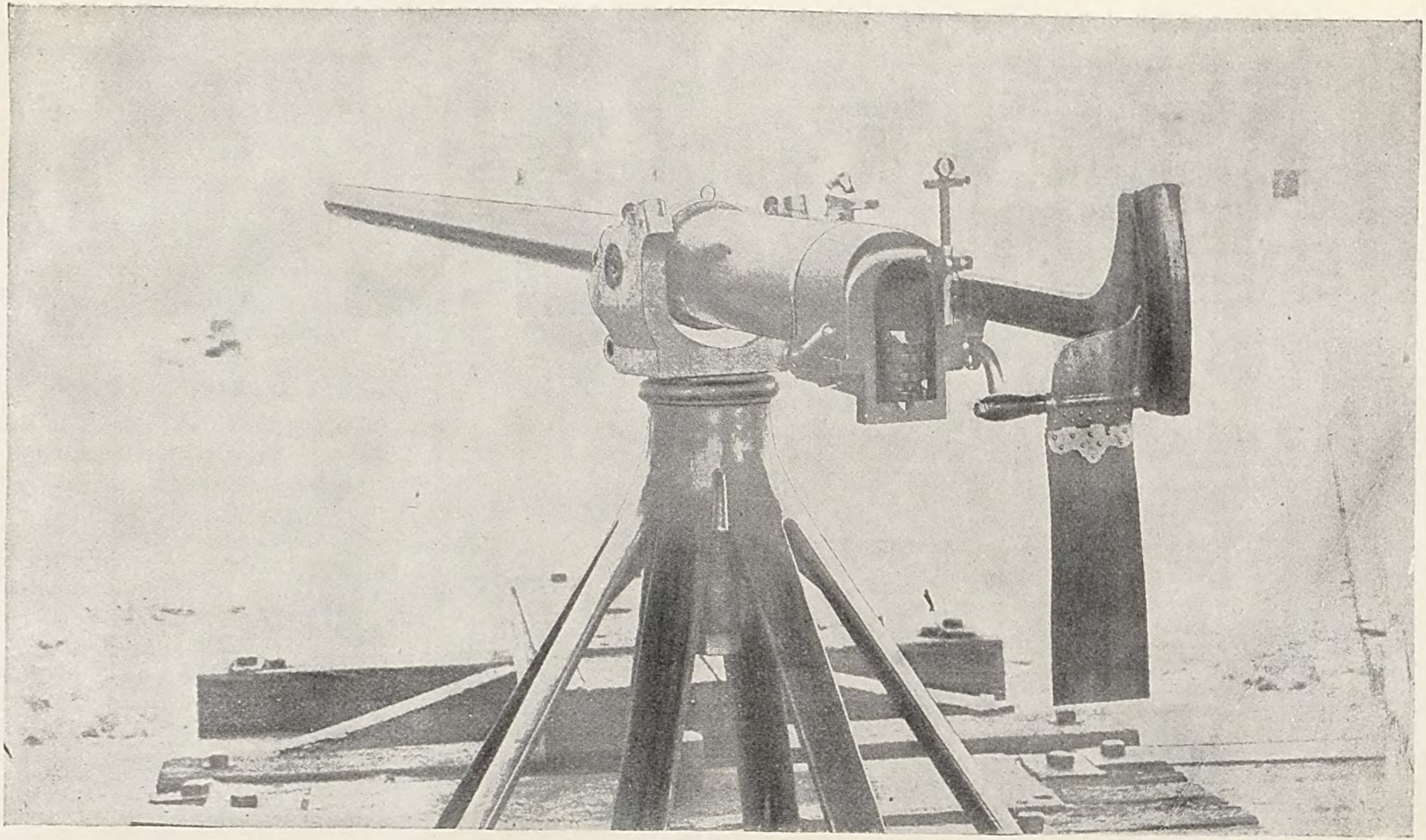
1. Steel shell. 2. Shrapnel. 3. Case shot. 4. Common shell. 5. Complete cartridge.



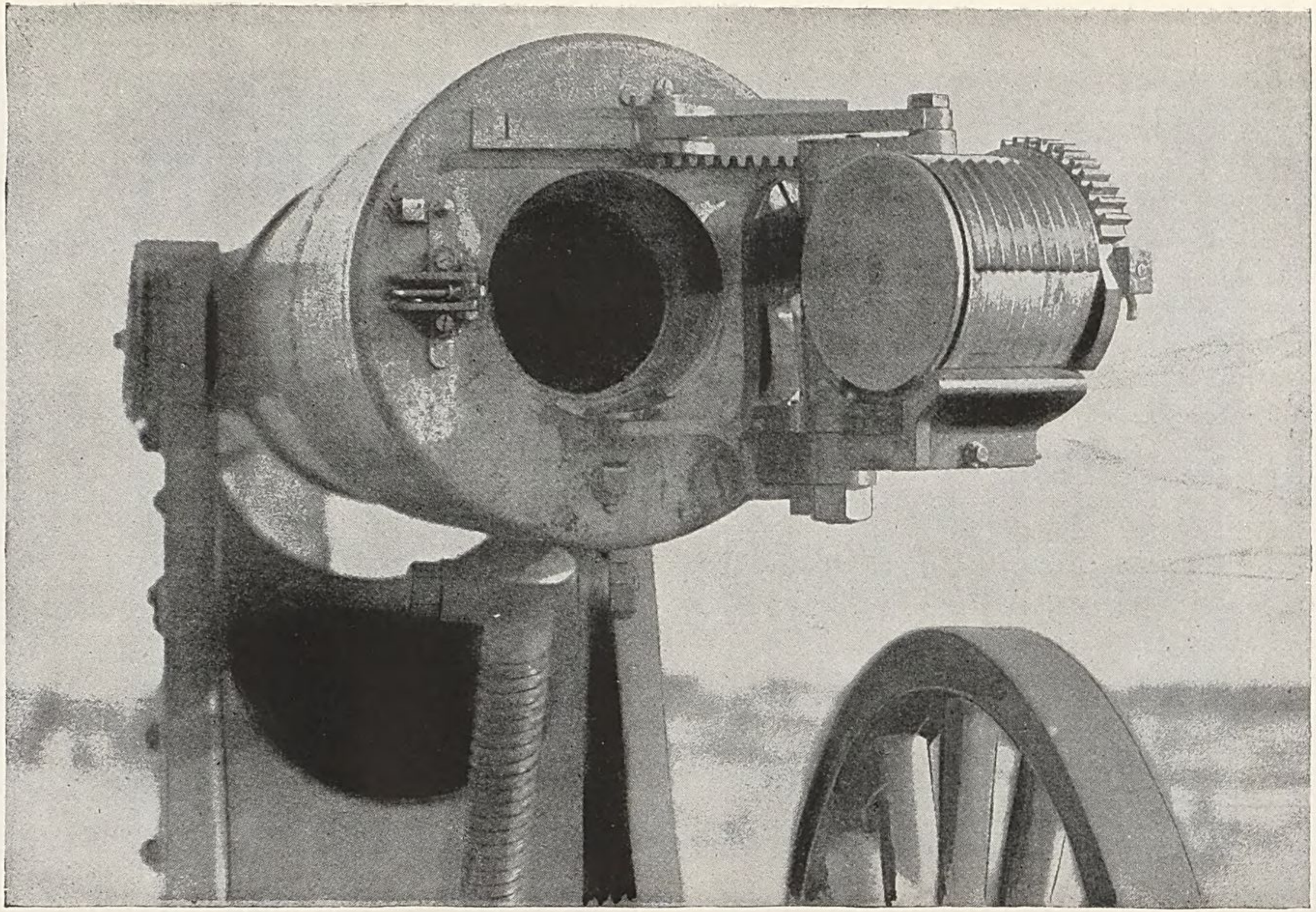
1. 37mm, 1 Pdr. 2. 47mm, 2½ Pdr. 3. 47mm, 3 Pdr. 4. 57mm, 6 Pdr. 5. 65mm, 9 Pdr.
6. 10cm, 33 Pdr.



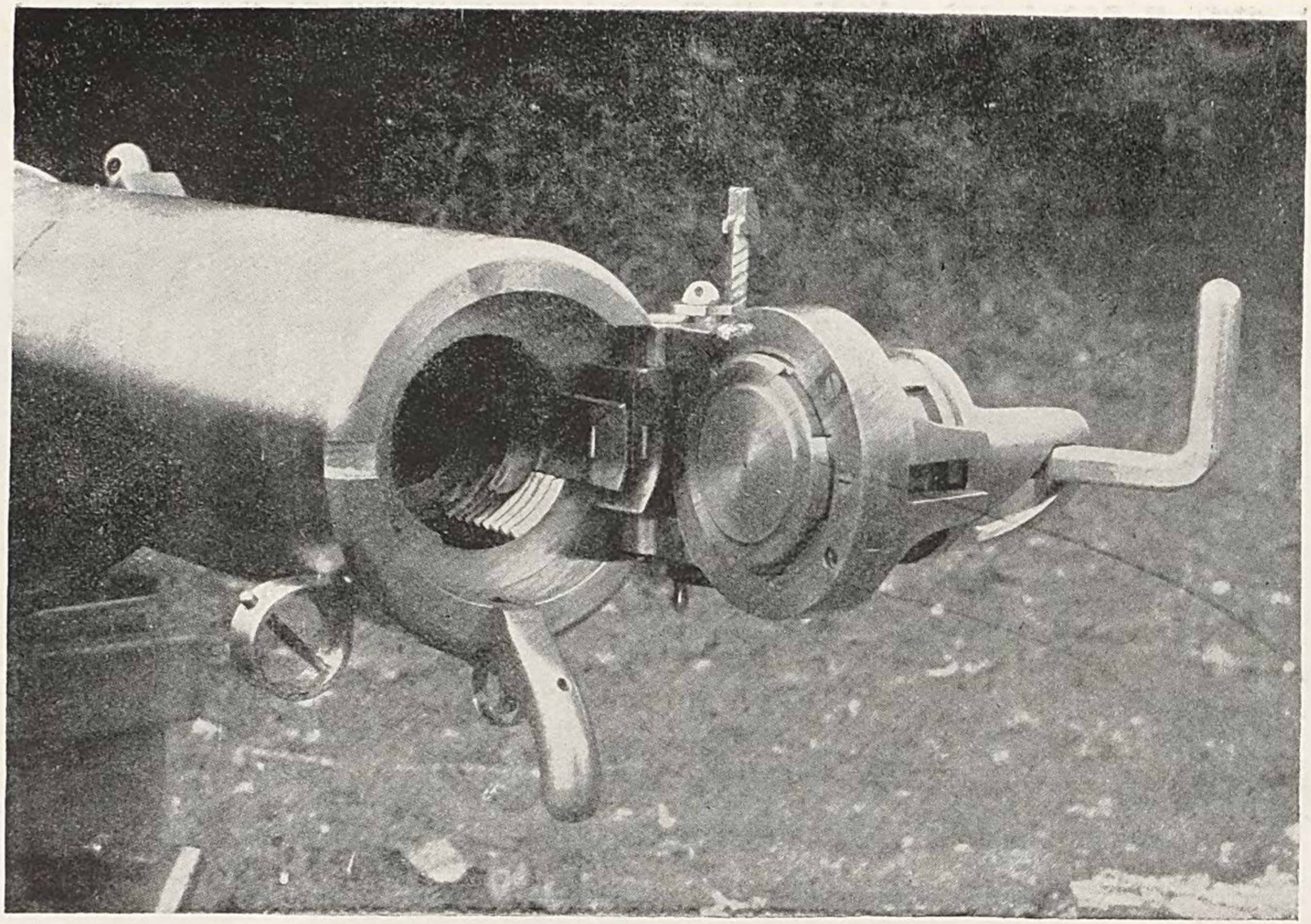
CANET R. F. BREECH MECHANISM.



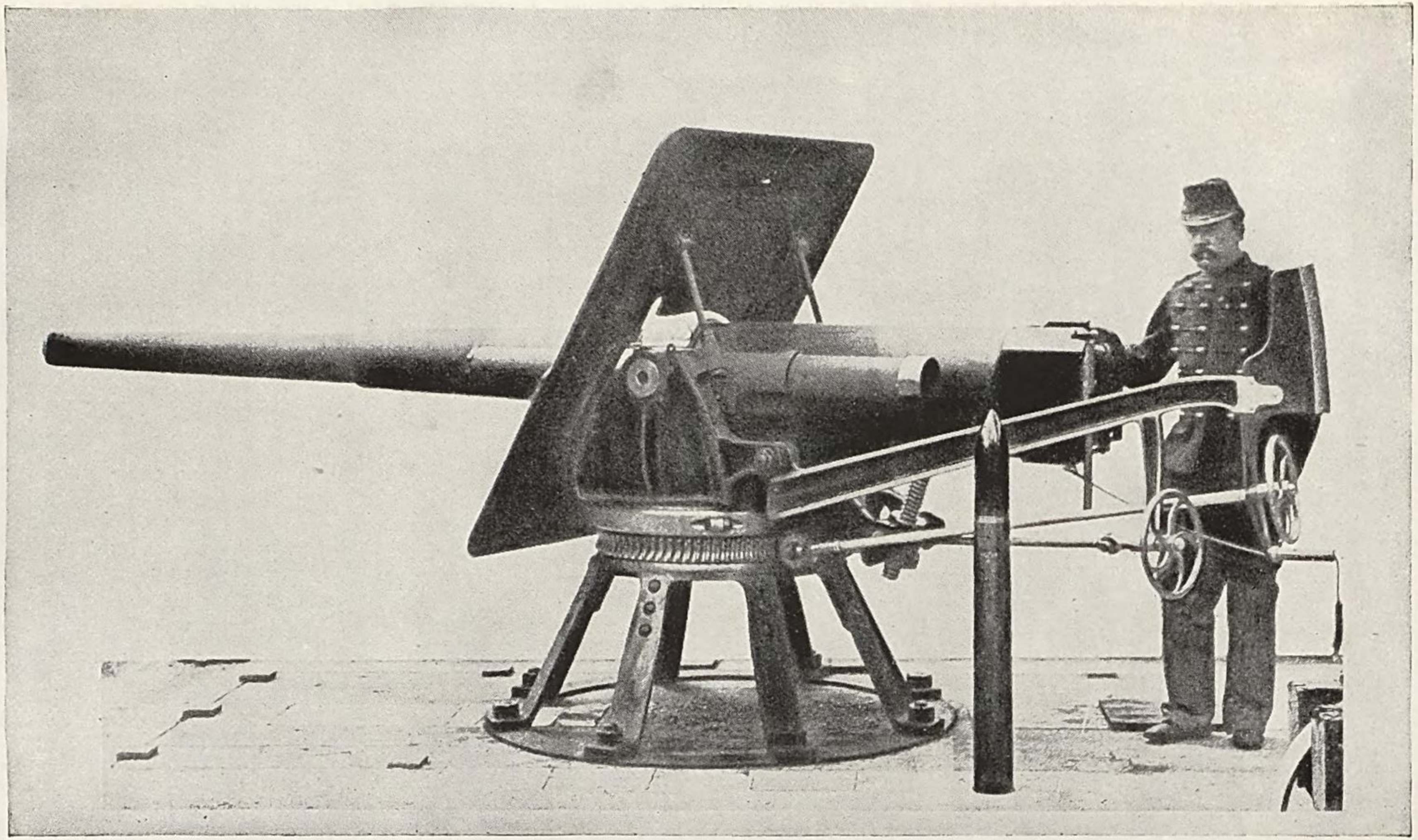
THE DRIGGS-SCHROEDER 6 PDR. R. F. BREECH MECHANISM.



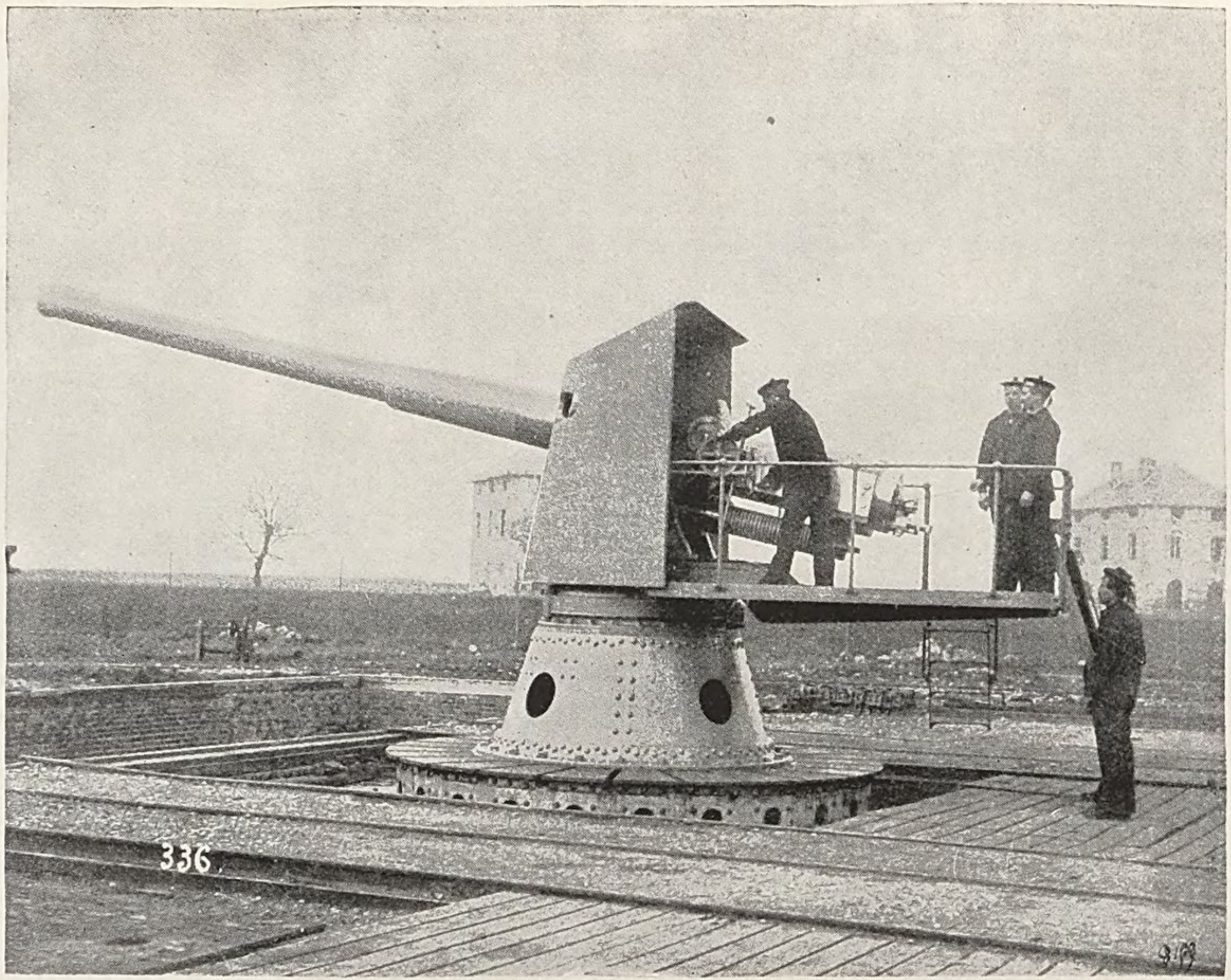
SEABURY R. F. BREECH MECHANISM ON 5″ SIEGE RIFLE, U. S. ARMY.



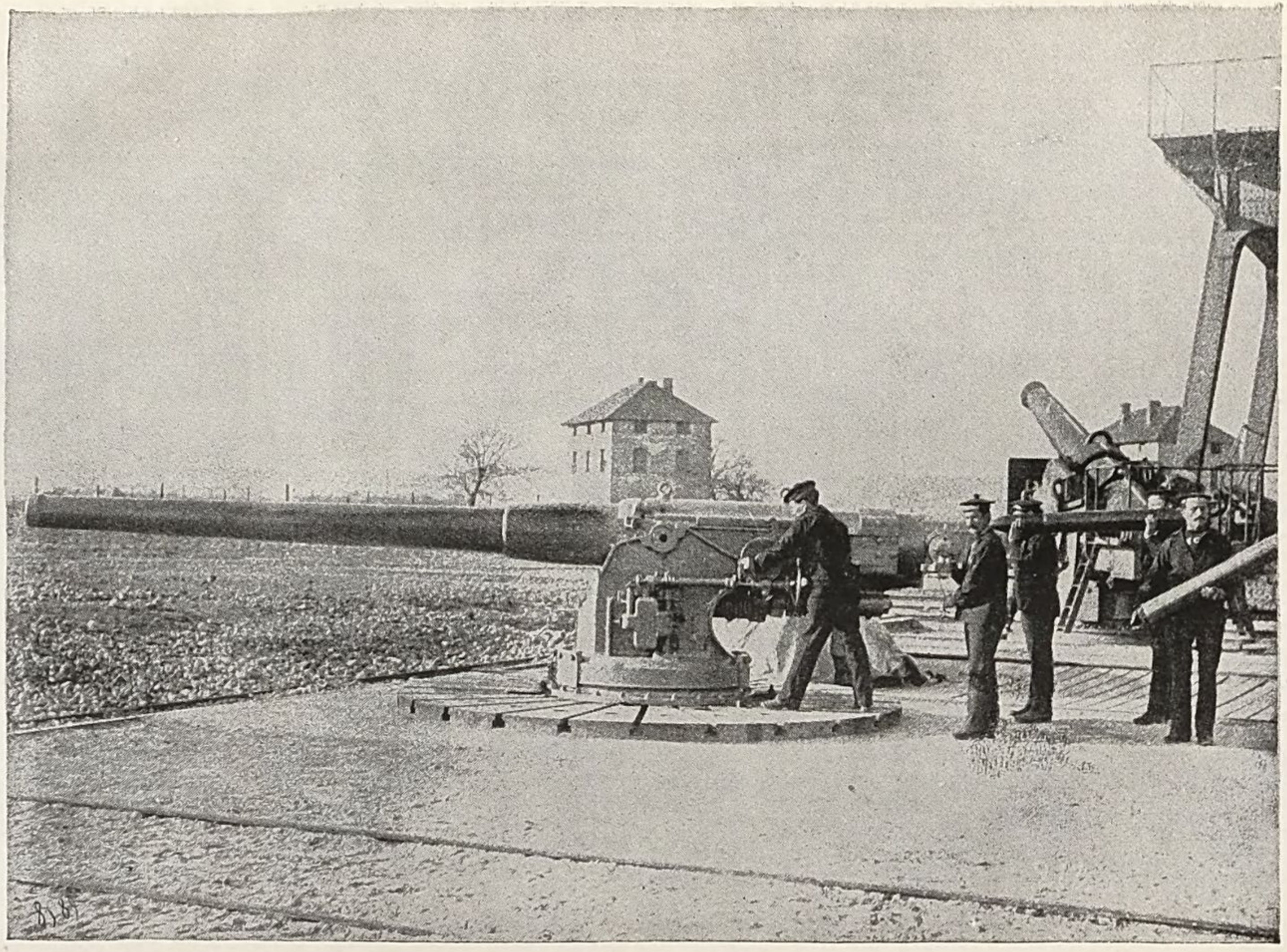
SEABURY 6 PDR. R. F. BREECH MECHANISM.



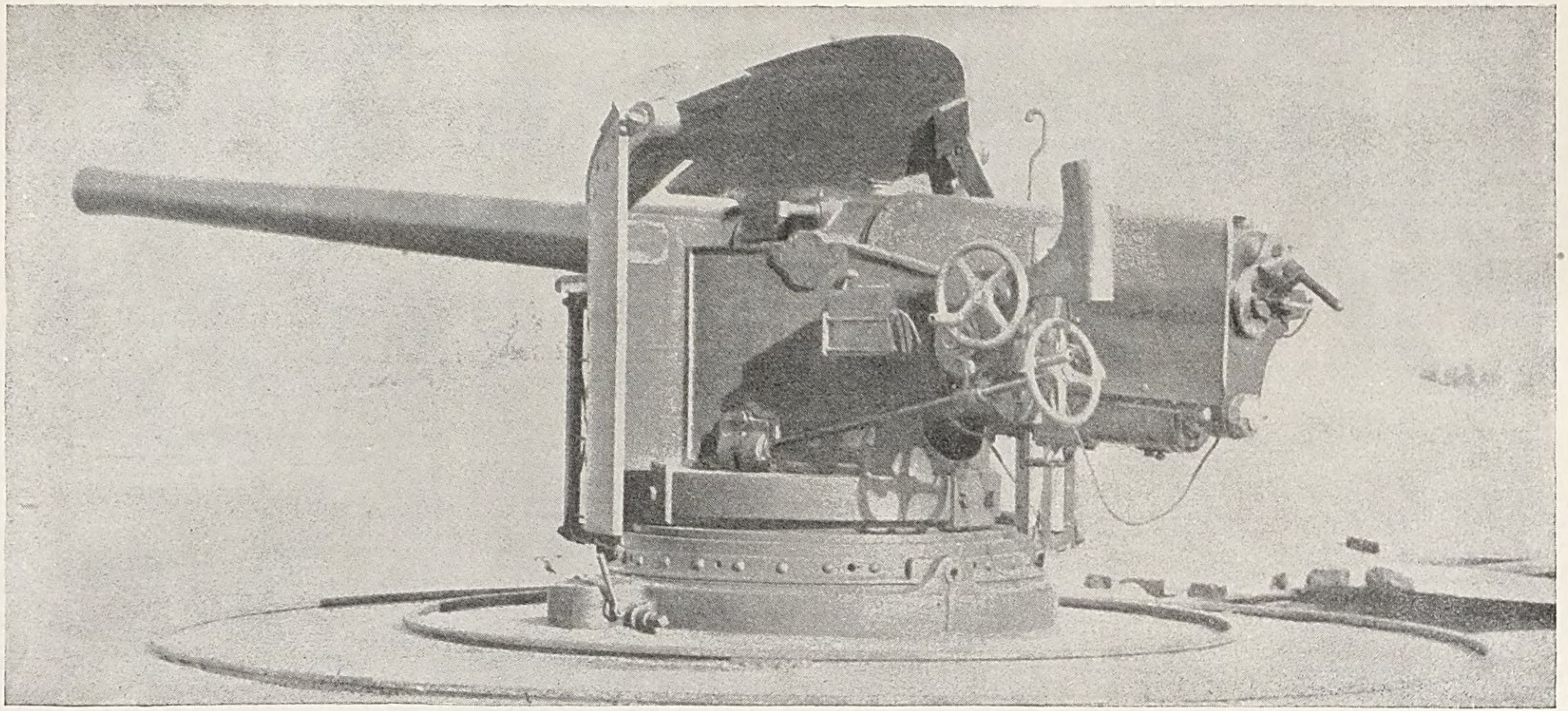
10cm 33 Pdr. on Center Pivot Deck Mount.



6 Inch 50 Calibre Canet R. F. Gun for Fortress Defence.



CANET 15cm R. F. GUN FOR SHIPS.



4.72 Inch Armstrong R. F. Gun on Balance Pillar Mount.

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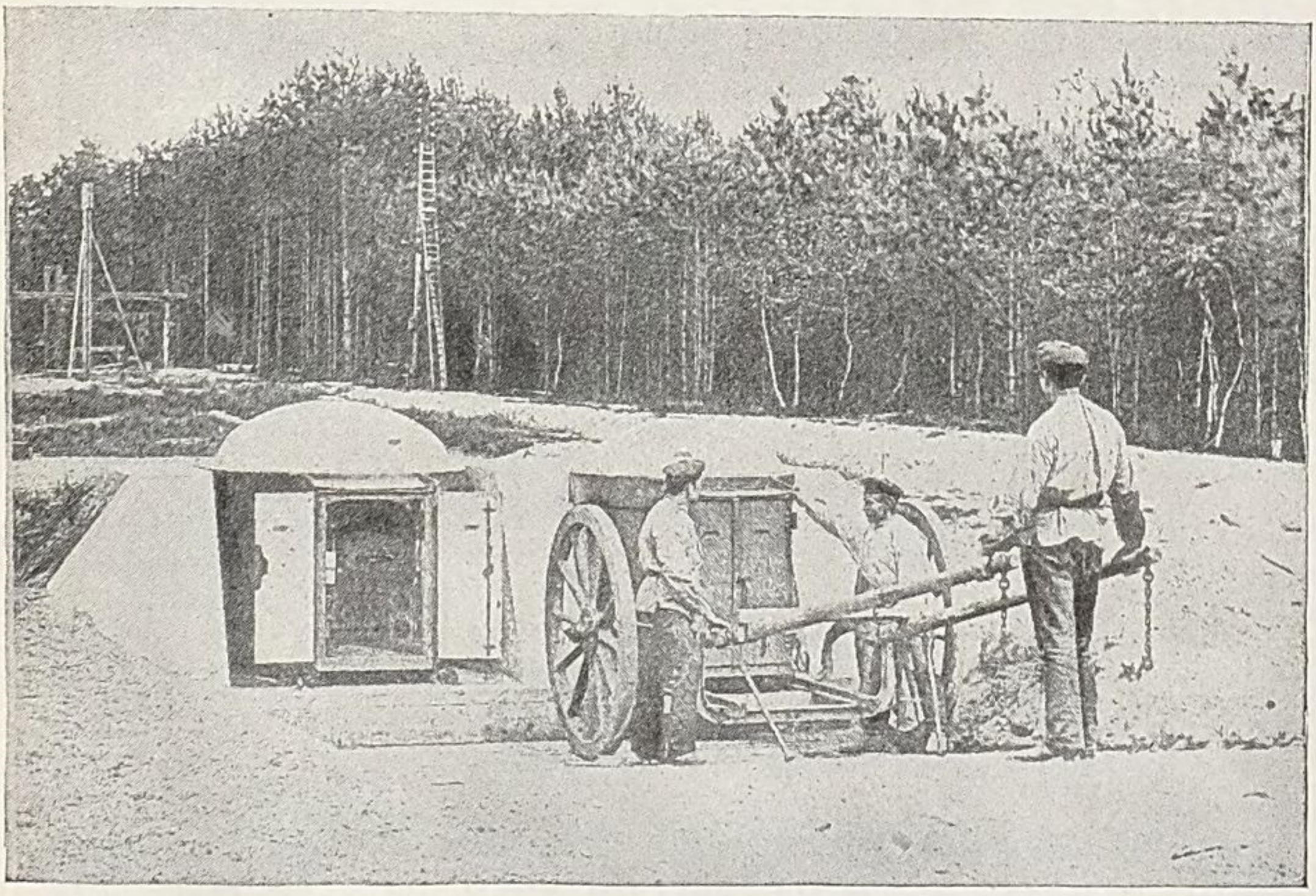
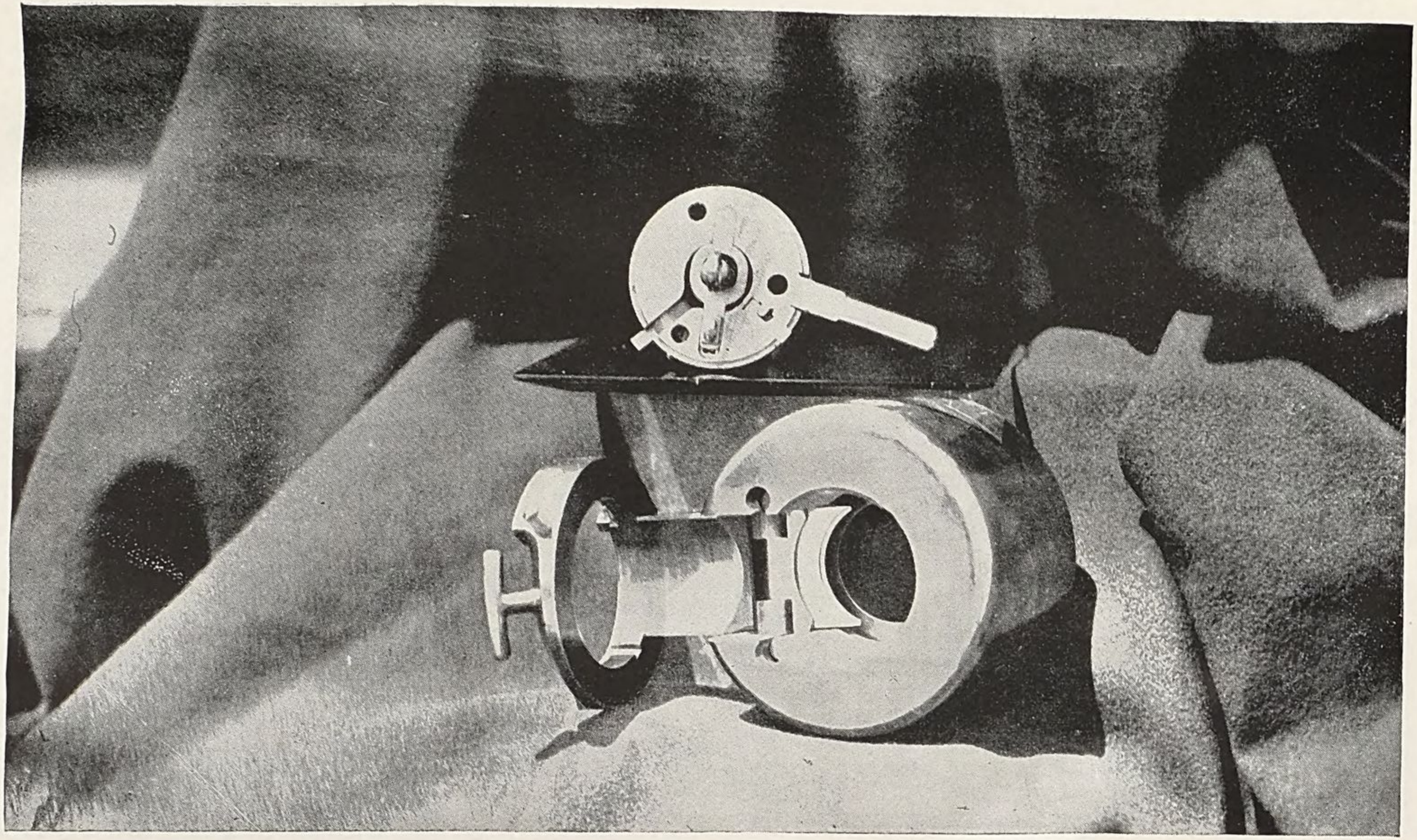
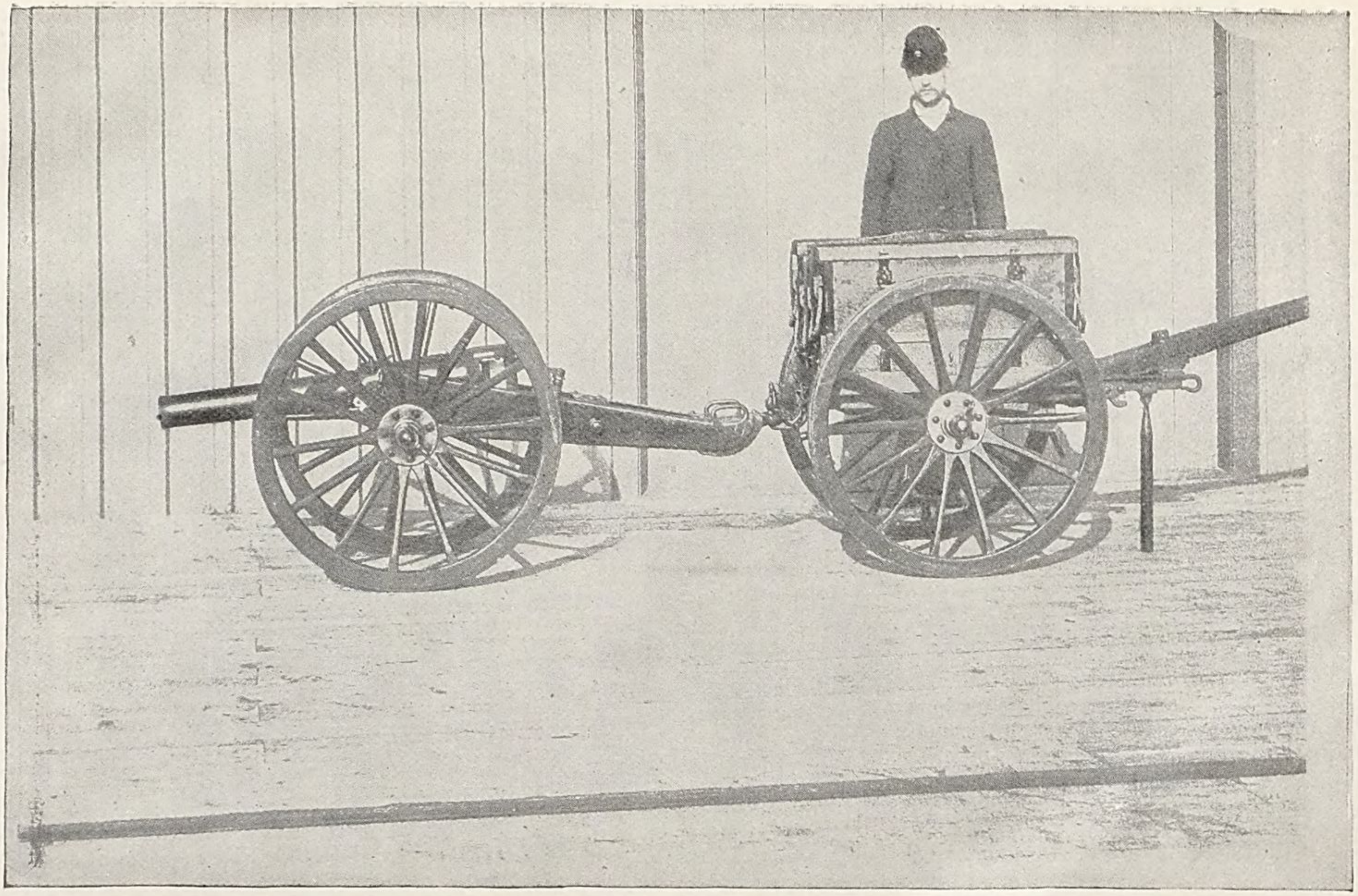
MOVABLE SHIELDED MOUNTING FOR 1.46 INCH 23 CALIBRE R. F. GUN. (GRUSON.)

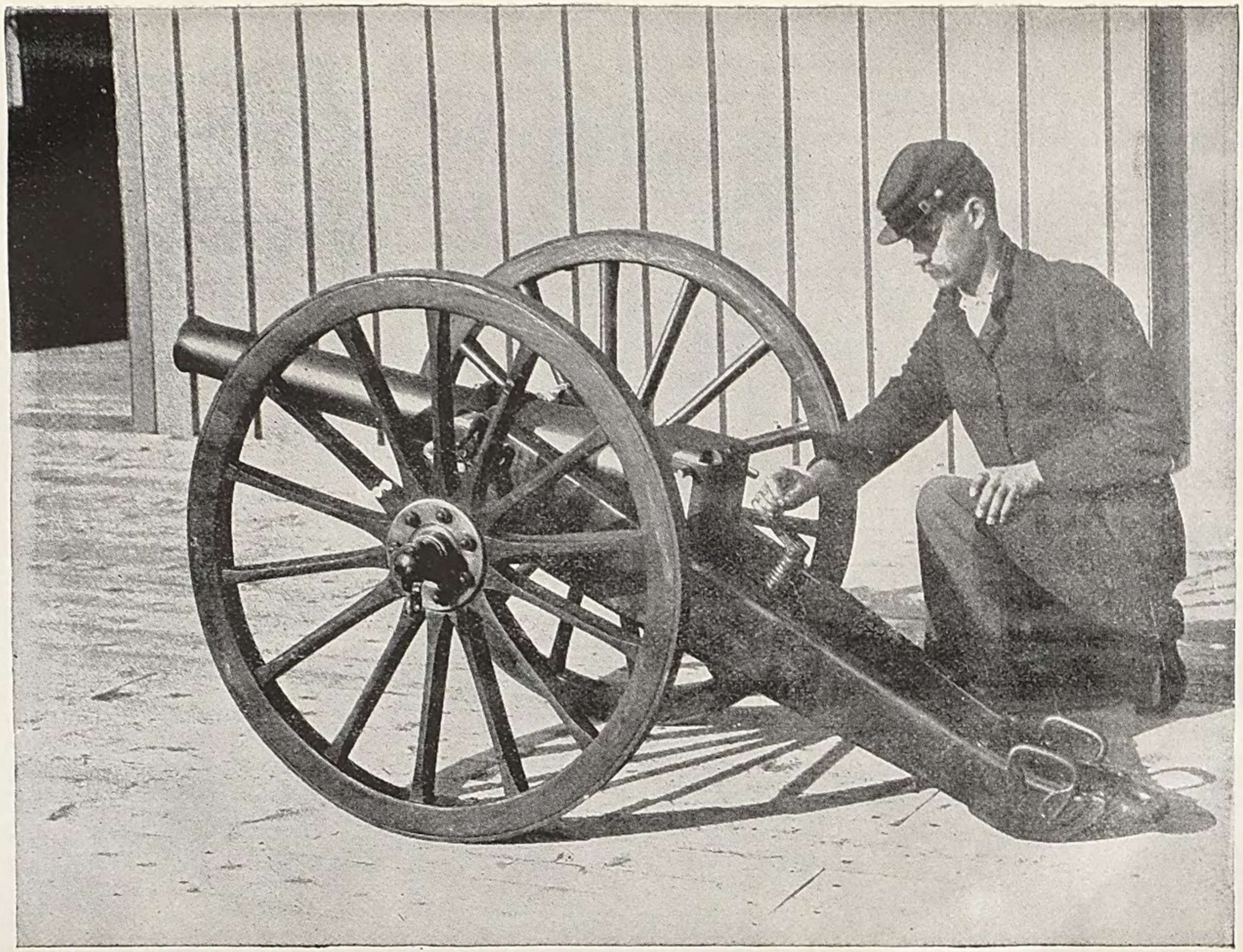


MOVABLE SHIELDED MOUNTING FOR 2.09 INCH 24 CALIBRE R. F. GUN. IN FIRING POSITION. (GRUSON.)

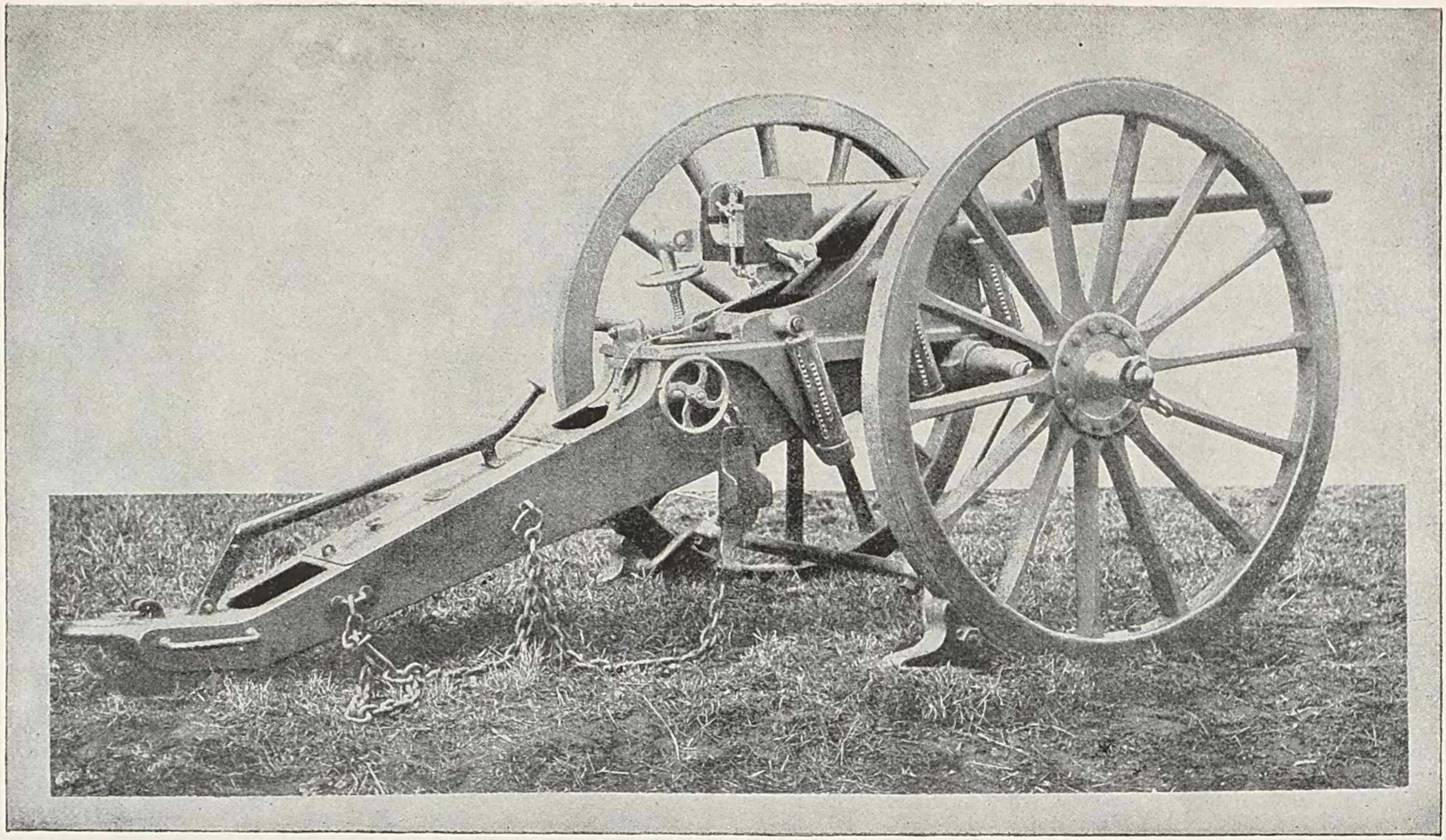




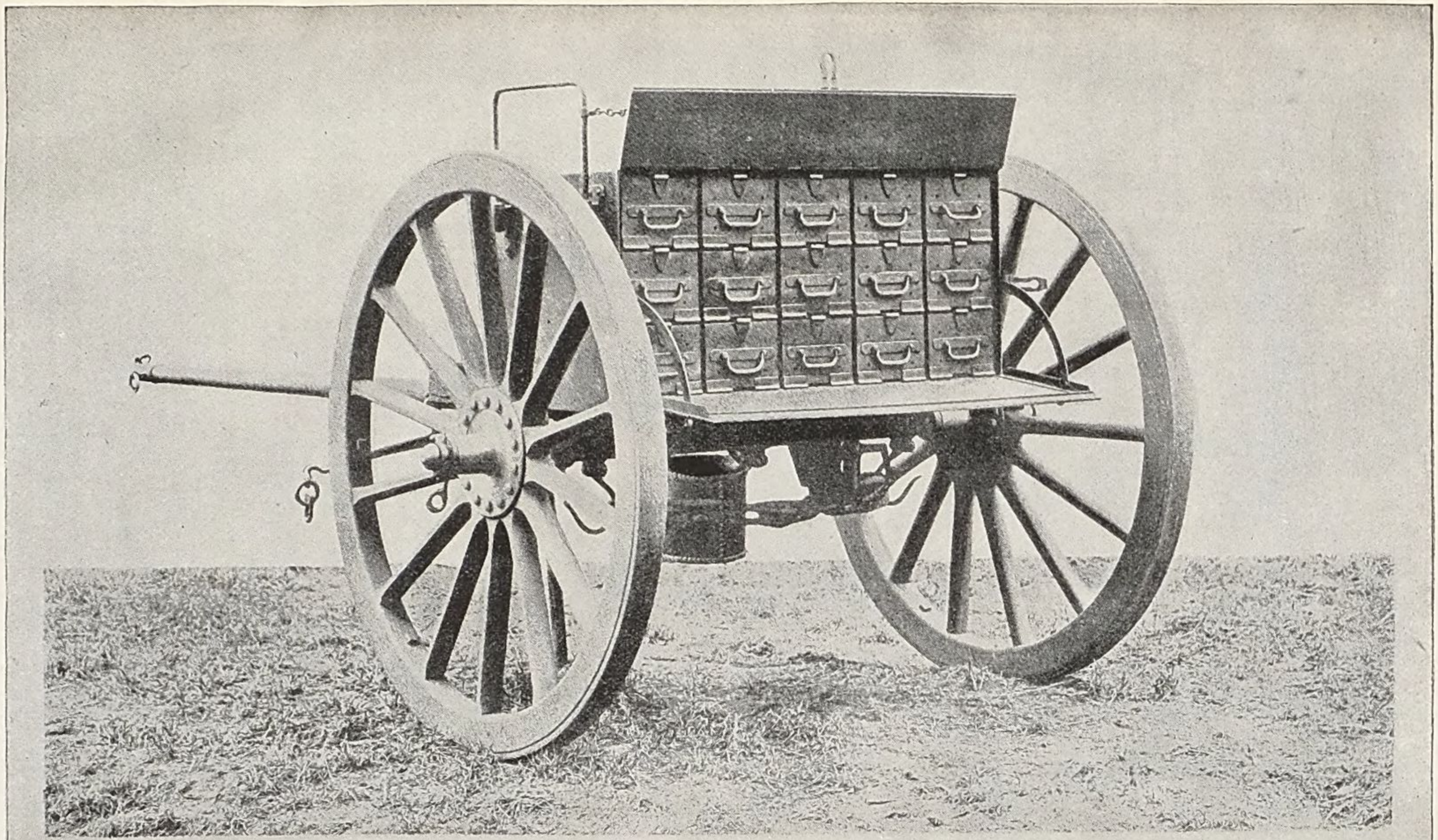
HOTCHKISS 3 INCH MOUNTAIN R. F. GUN AND LIMBER, U. S. ARMY.



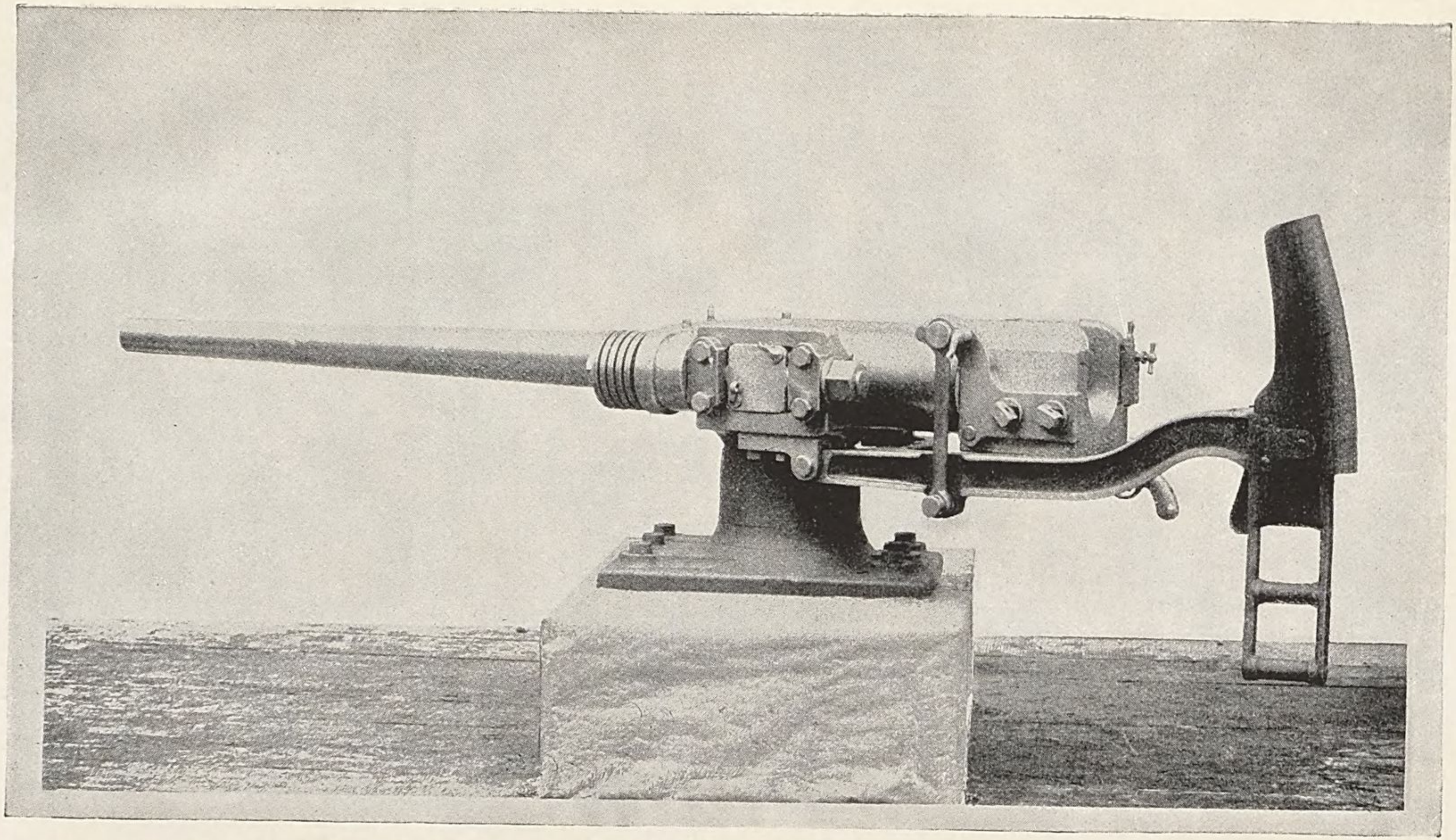
HOTCHKISS 3 INCH MOUNTAIN R. F. GUN AND CARRIAGE.



HOTCHKISS FIELD CARRIAGE FOR R. F. GUN, 3 PDR.

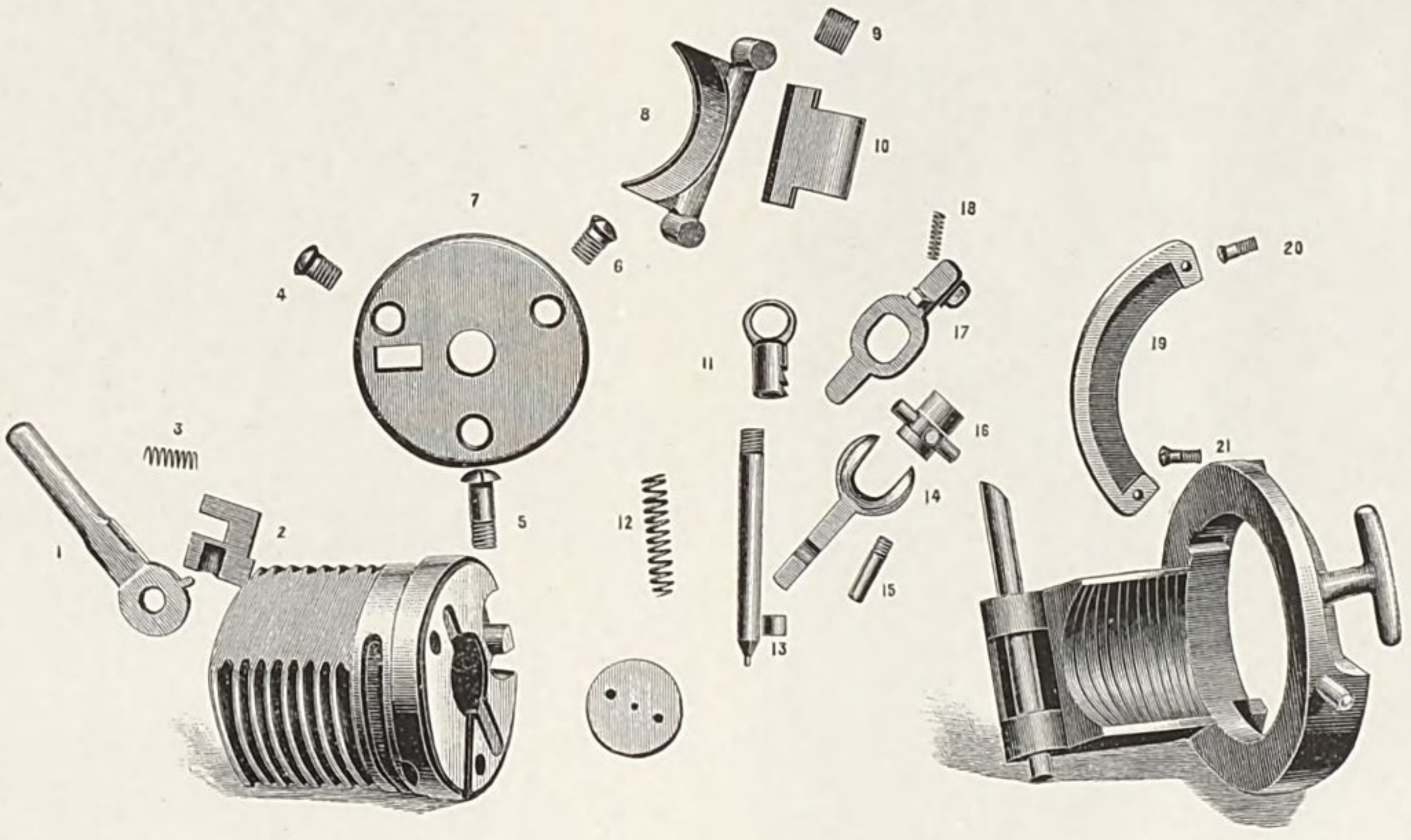


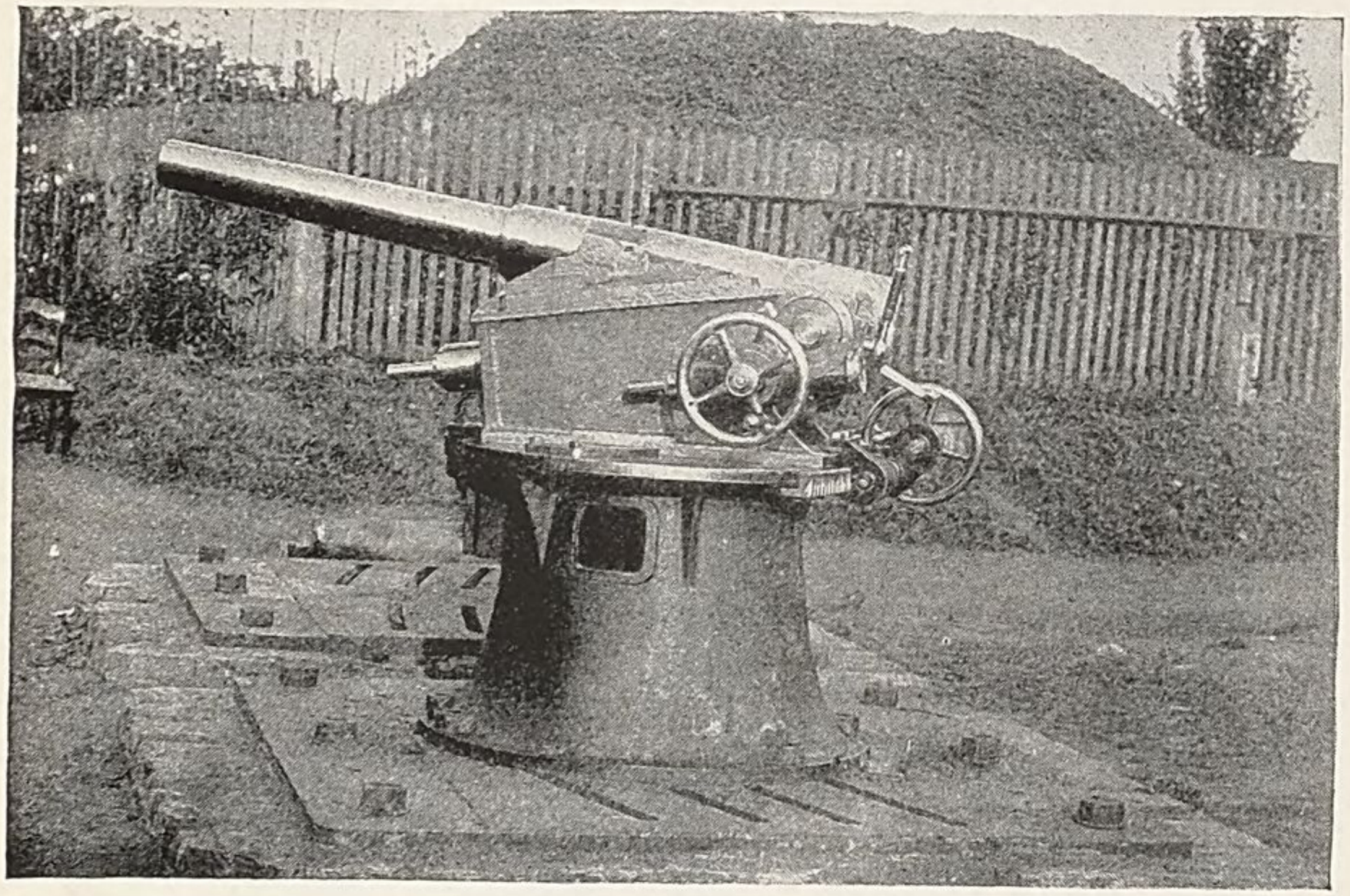
HOTCHKISS FIELD LIMBER FOR R. F. GUN, 3 PDR.



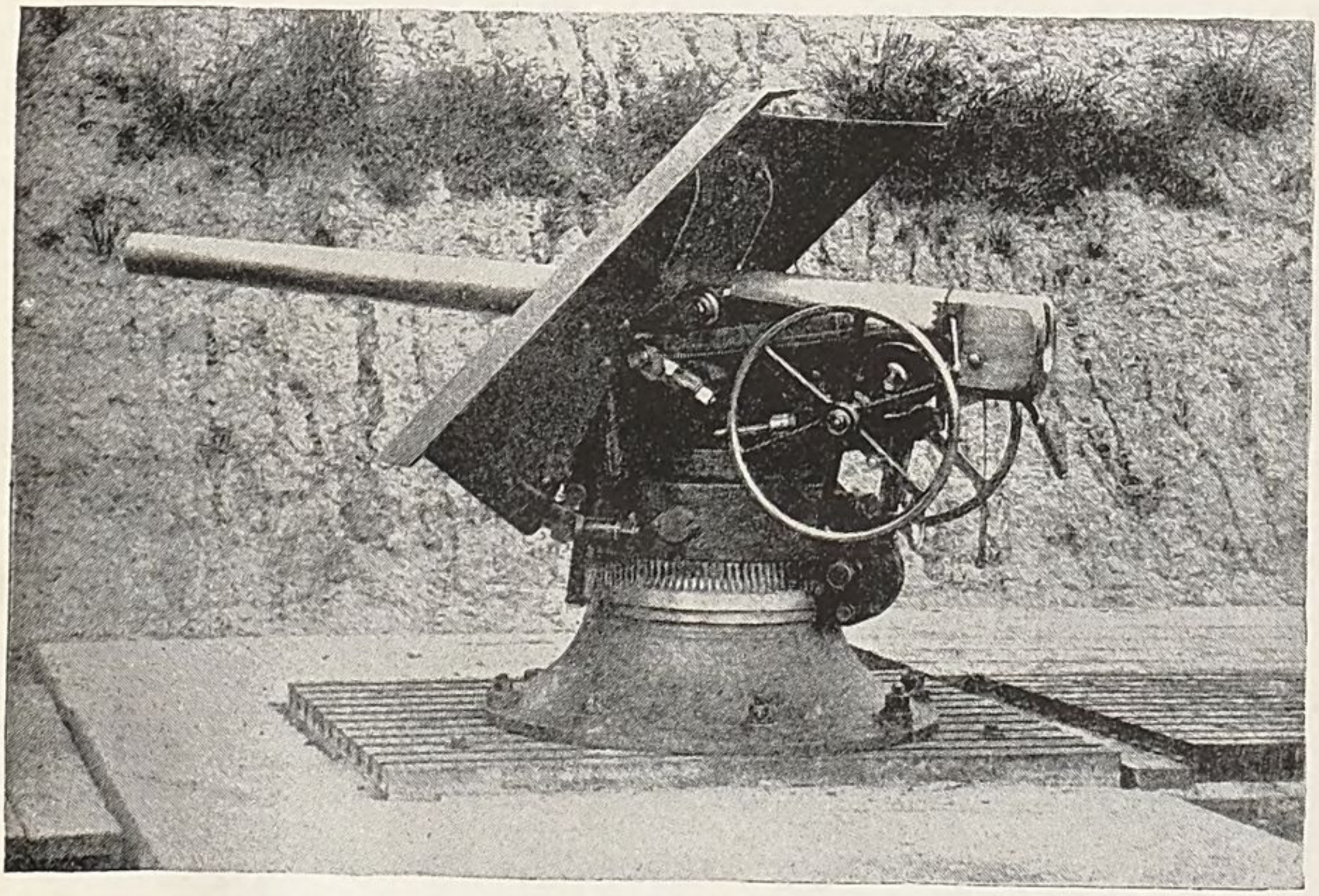
6 PDR. EMBRASURE MOUNT.

PLATE A.



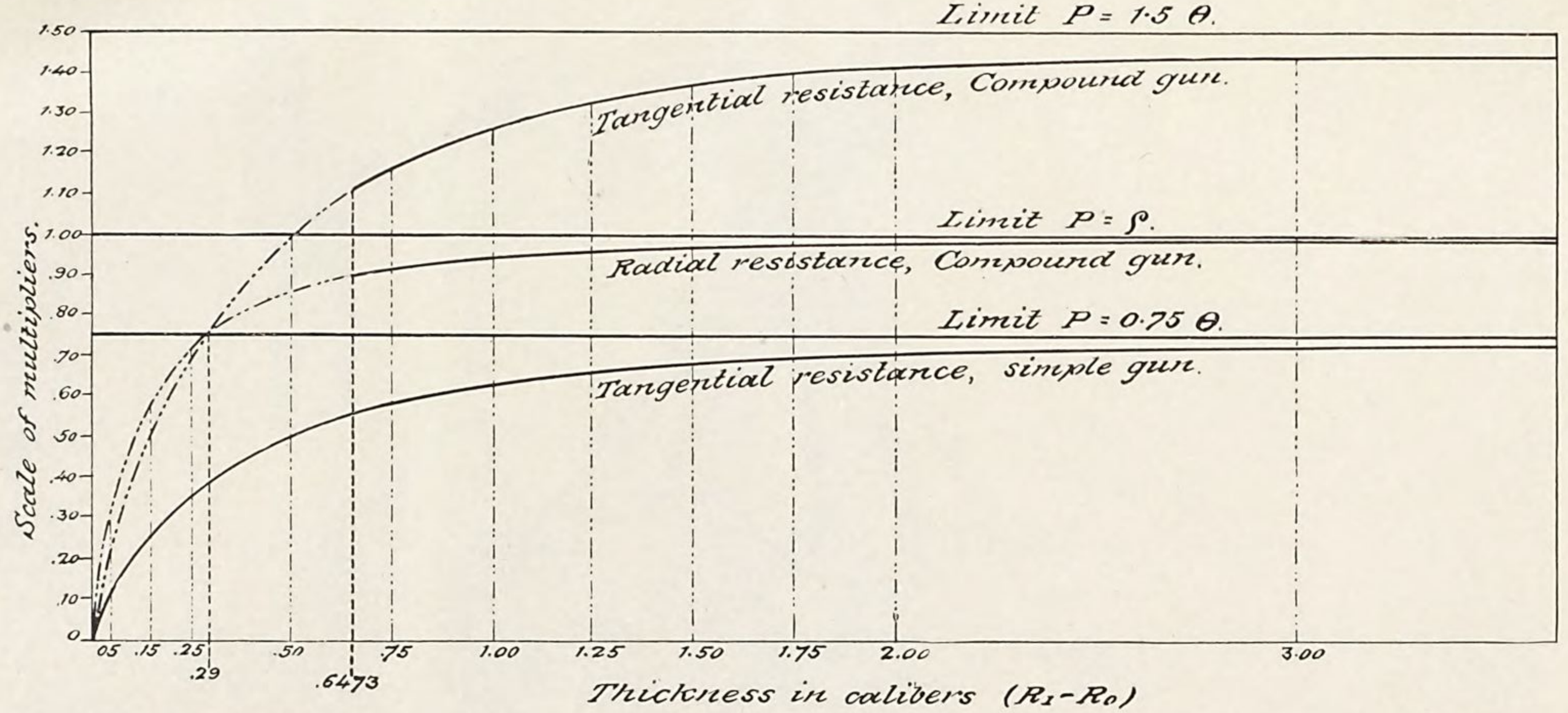


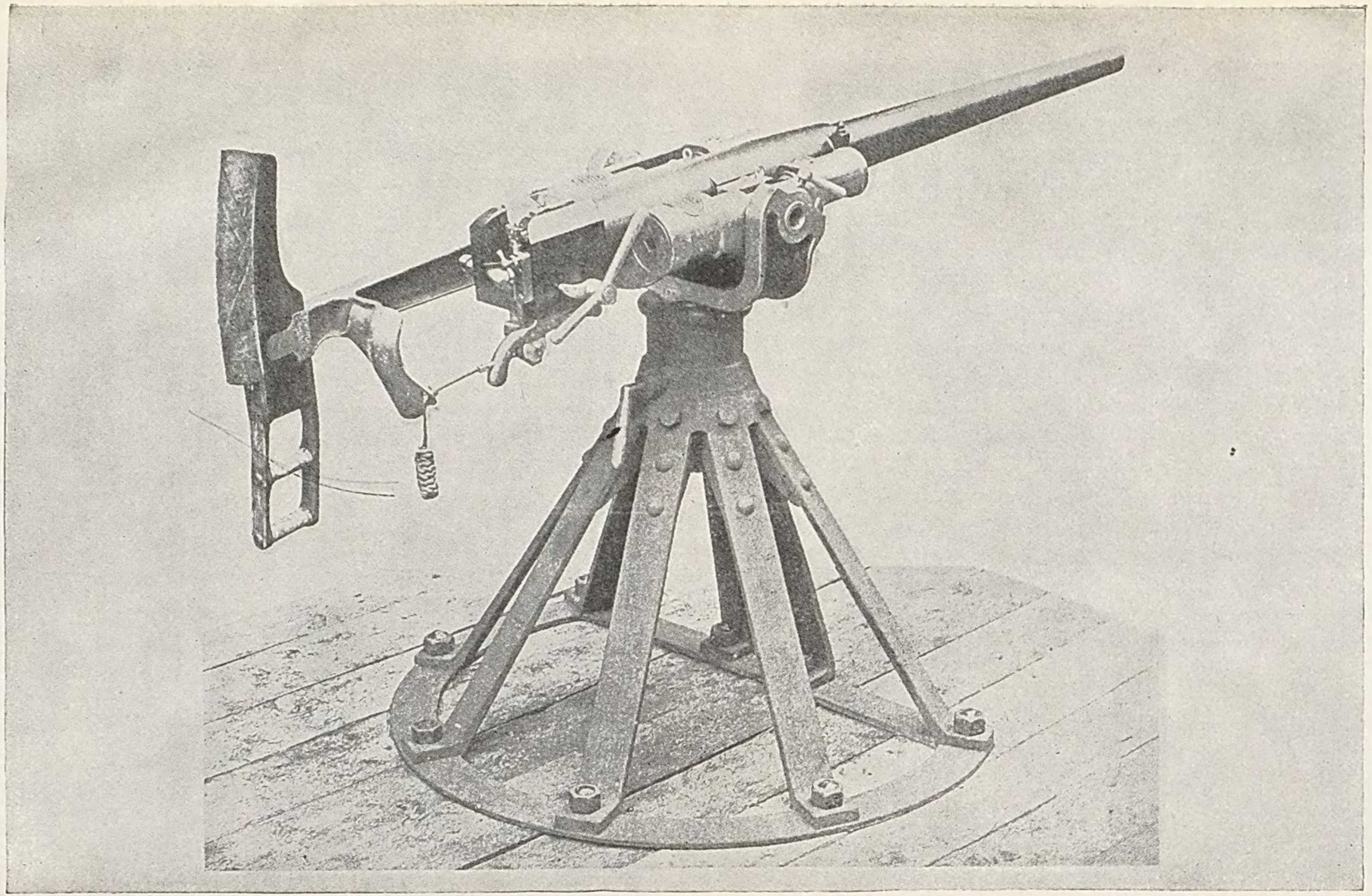
CONE MOUNTING WITH HYDRAULIC BRAKES FOR 2.95 INCH 25 CALIBRE R. F. GUN. (GRUSON.)



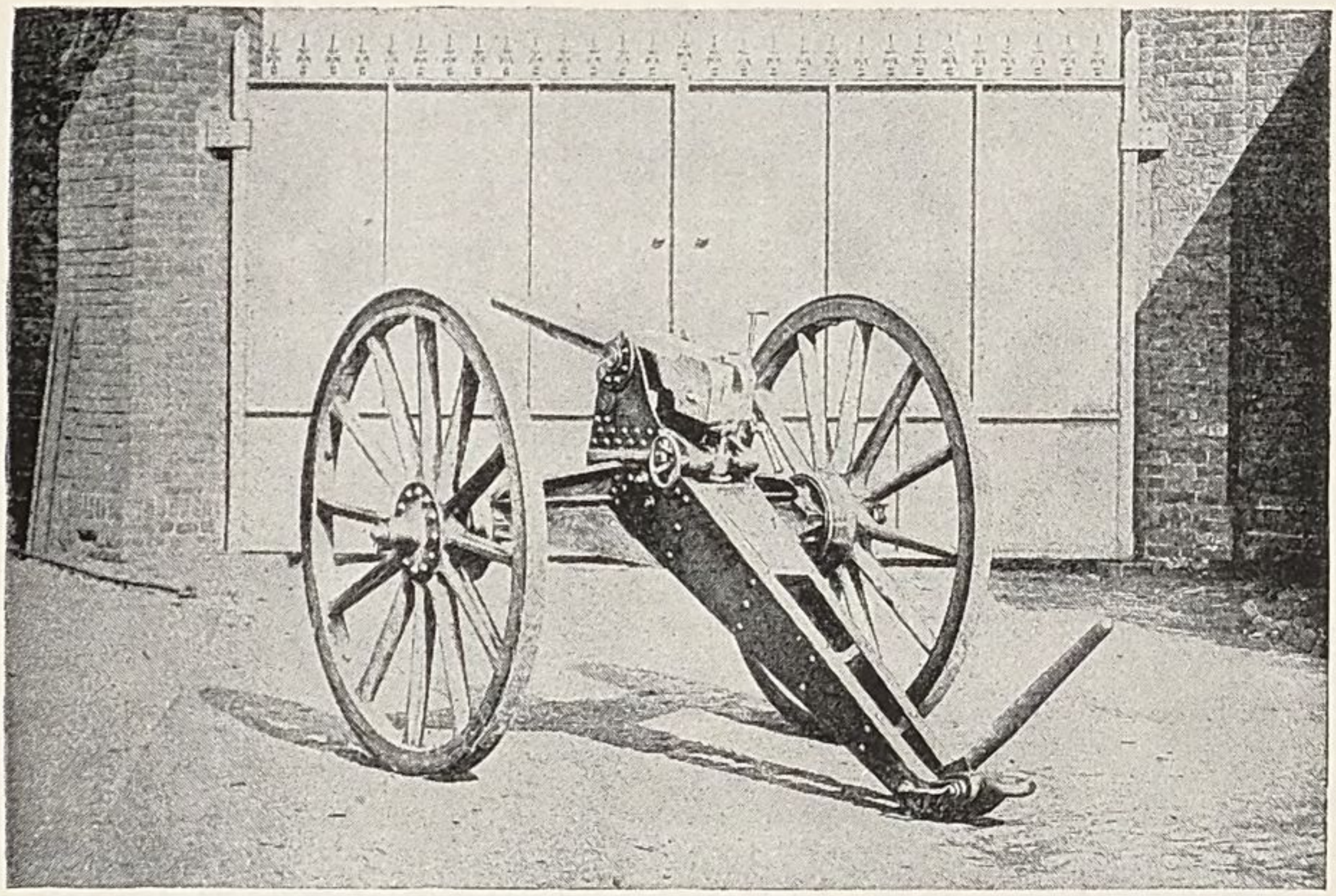
SHIPS MOUNTING FOR 3.23 INCH 35 CALIBRE R. F. GUN. (GRUSON.)

Fig. 1. Elastic resistance of guns.

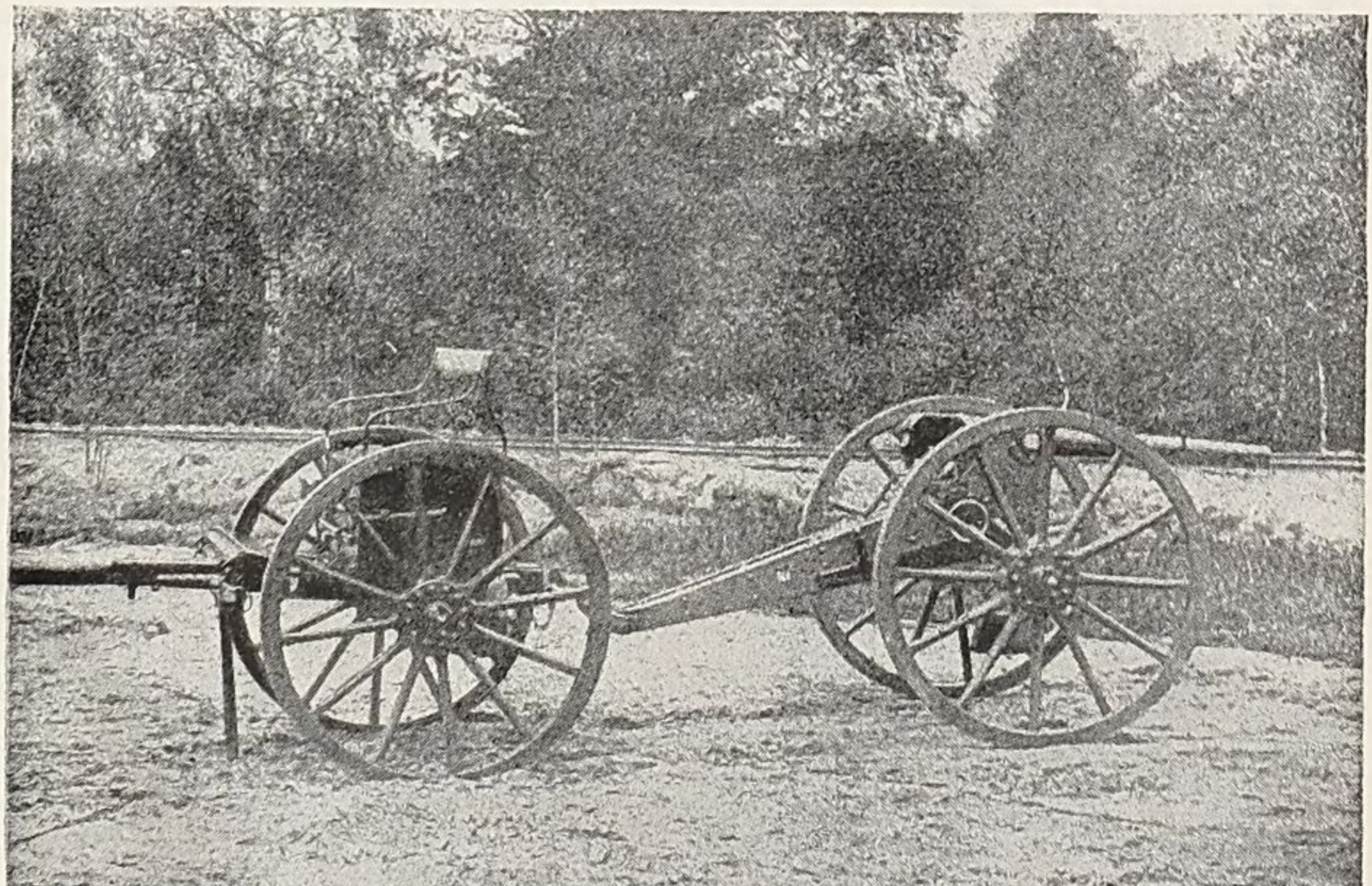




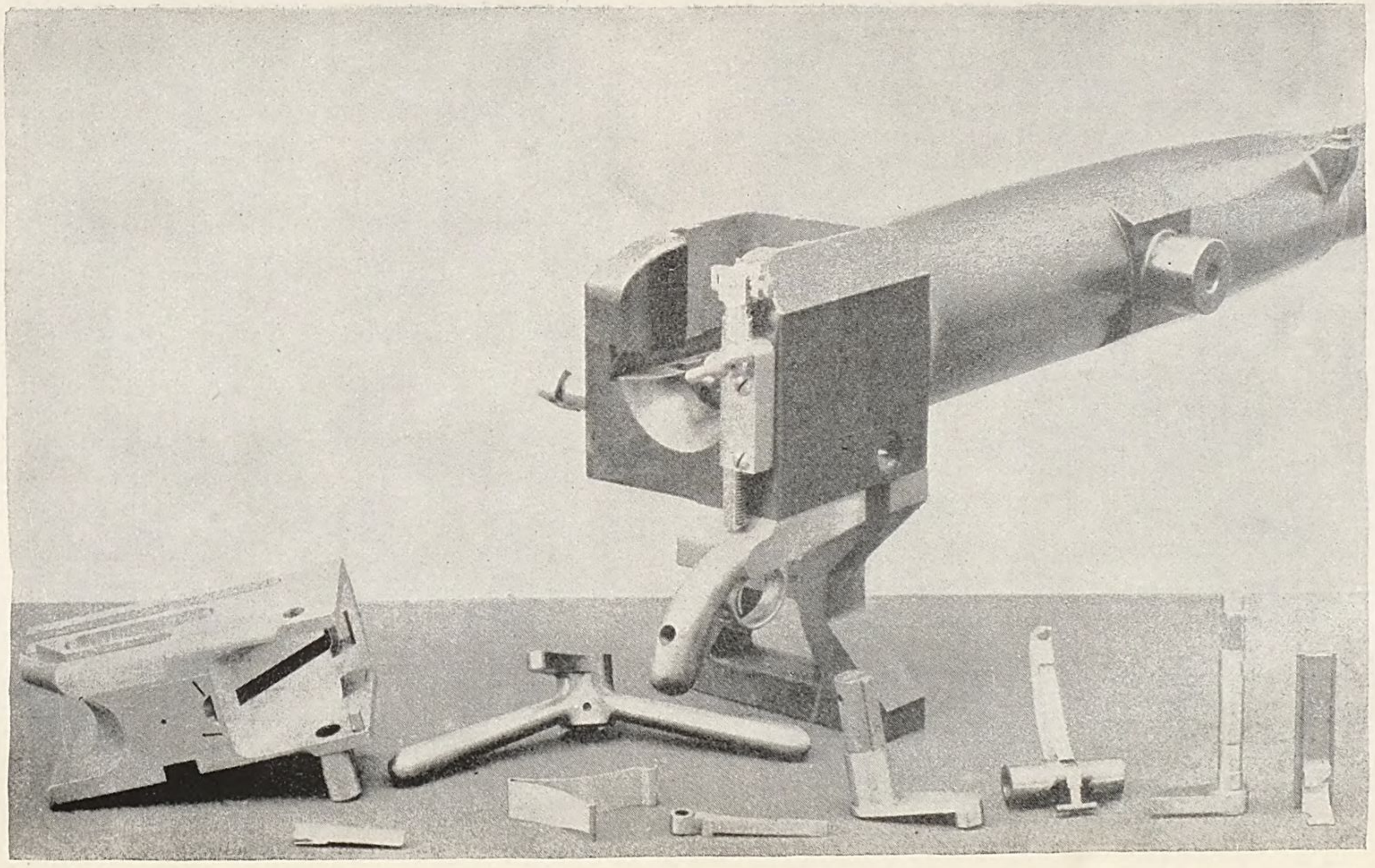
3 Pdr. Hotchkiss on Recoil Mount.



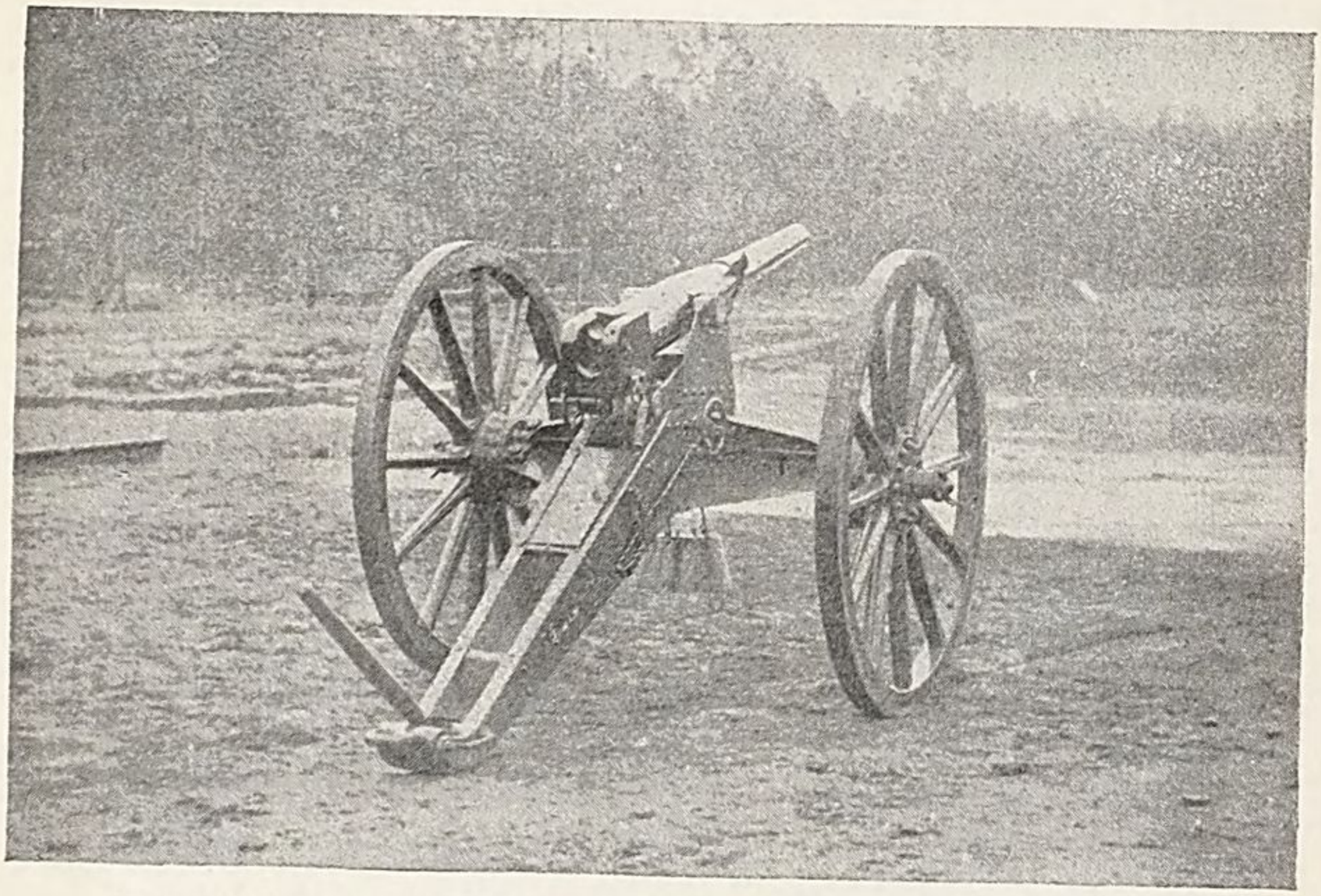
THE 1.85 INCH 30 CALIBRE R. F. GUN ON ITS FIELD CARRIAGE. (GRUSON.)



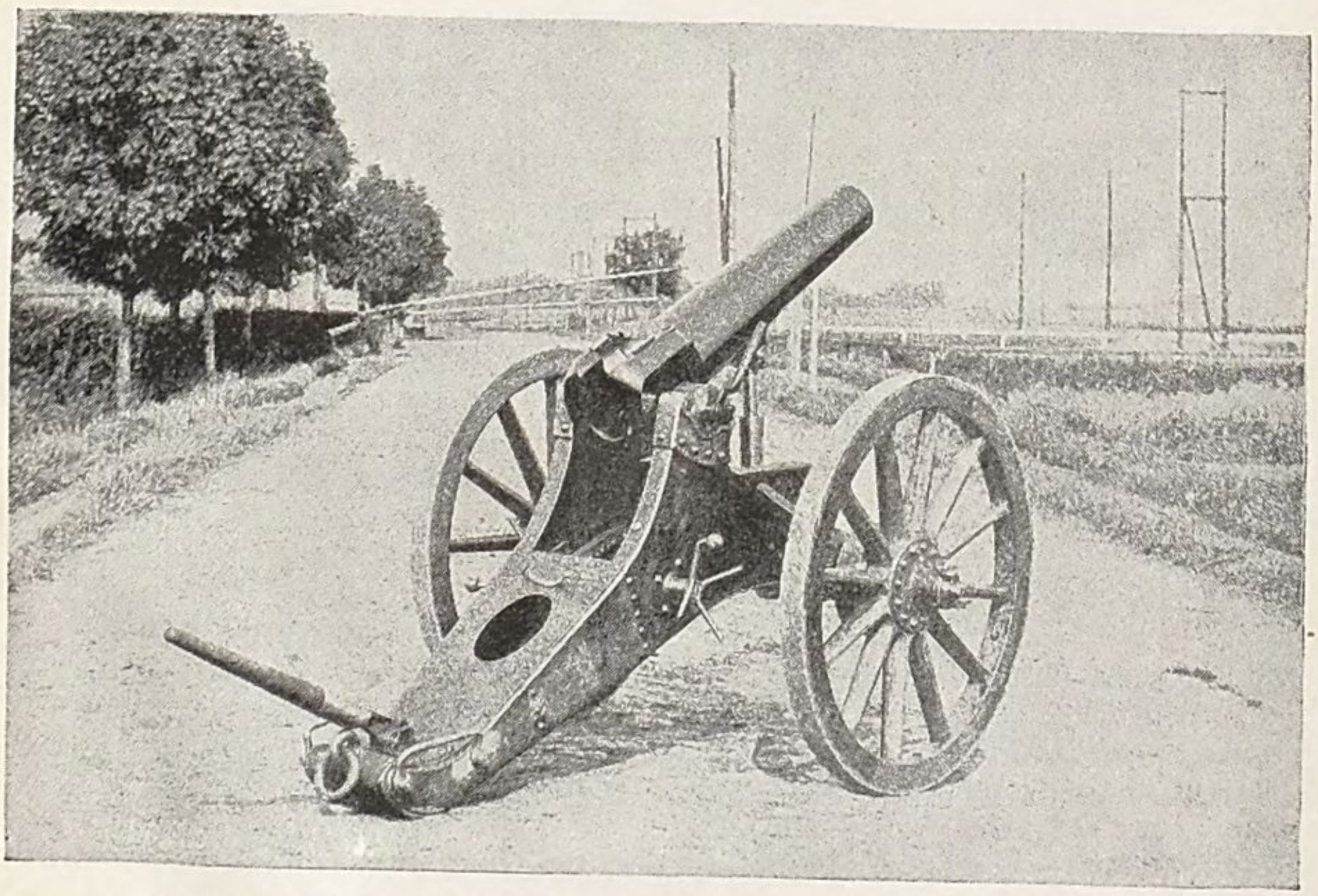
2.09 INCH 30 CALIBRE R. F. GUN WITH FIELD CARRIAGE AND LIMBER. (GRUSON.)



MECHANISM OF HOTCHKISS BREECHBLOCK.



THE 2.24 INCH 30 CALIBRE R. F. GUN ON ITS FIELD CARRIAGE. (GRUSON.)



13 CALIBRE 4.72 INCH FIELD HOWITZER ON ITS CARRIAGE. (GRUSON.)

Fig. 2. Initial tension in solid gun.

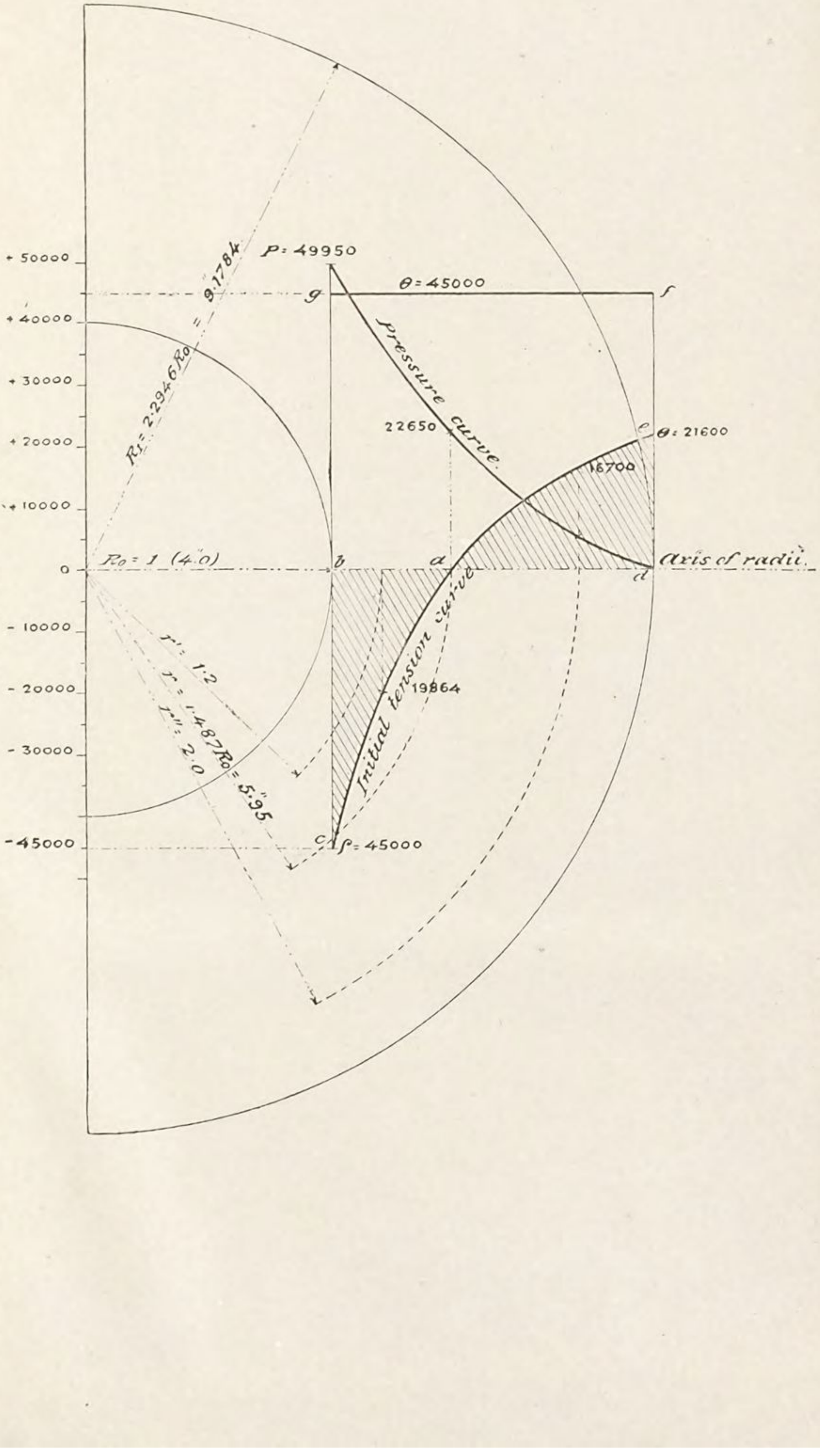
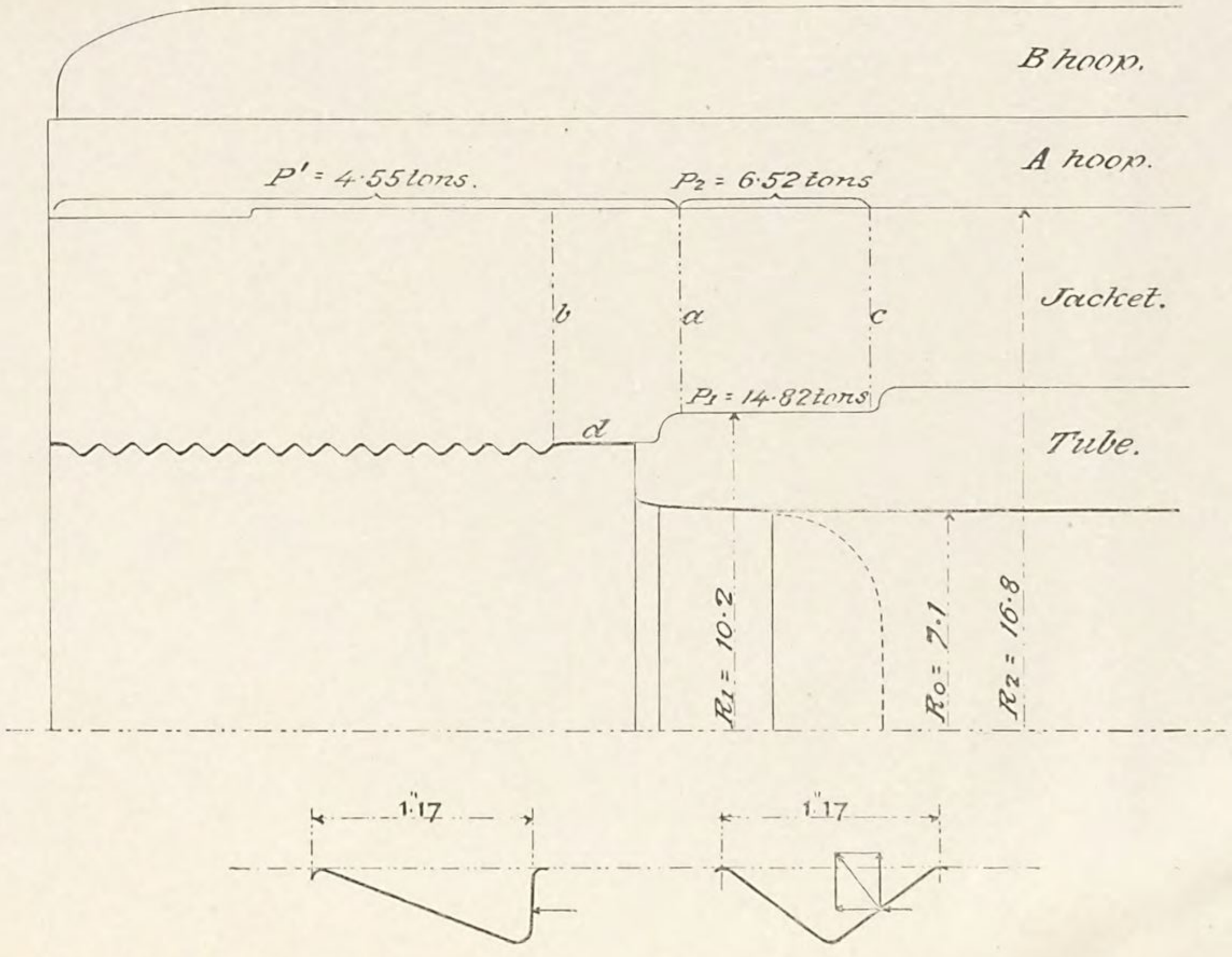


Fig. 3. Longitudinal resistance.



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MDZ Münchener DigitalisierungsZentrum Digitale Bibliothek

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